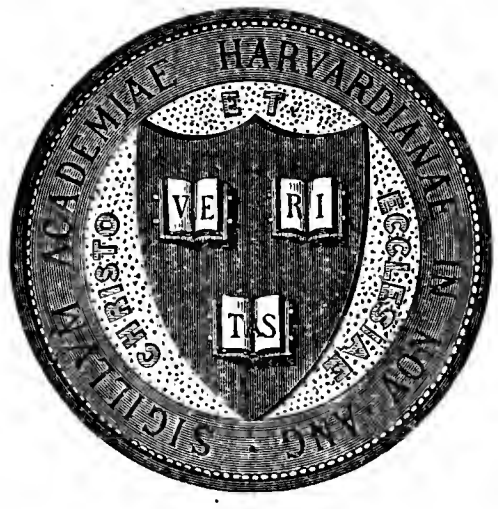


CONTRIBUTIONS FROM THE ARNOLD ARBORETUM
OF HARVARD UNIVERSITY

I

THE HYPODERMATACEAE OF CONIFERS

BY

GRANT DOOKS DARKER

WITH TWENTY-SEVEN PLATES

PUBLISHED BY
THE ARNOLD ARBORETUM OF HARVARD UNIVERSITY
JAMAICA PLAIN, MASS., U.S.A.
1932

CONTRIBUTIONS FROM THE ARNOLD ARBORETUM OF HARVARD UNIVERSITY

A publication issued at irregular intervals by the Arnold Arboretum of Harvard University.

The issues of this publication can be obtained from the Arnold Arboretum, Jamaica Plain, Mass., U. S. A. All correspondence relating to exchange for publications of institutions and societies should be addressed to the Librarian, Arnold Arboretum, Jamaica Plain, Mass., U. S. A.

Printed by the Eliot Press, Jamaica Plain, Mass., U. S. A.

THE HYPODERMATACEAE OF CONIFERS

CONTRIBUTIONS FROM THE ARNOLD ARBORETUM
OF HARVARD UNIVERSITY

I

THE HYPODERMATACEAE OF CONIFERS

BY

GRANT DOOKS DARKER

WITH TWENTY-SEVEN PLATES

PUBLISHED BY
THE ARNOLD ARBORETUM OF HARVARD UNIVERSITY
JAMAICA PLAIN, MASS., U.S.A.
1932

CONTRIBUTIONS FROM THE ARNOLD ARBORETUM
OF HARVARD UNIVERSITY

No. I, pp. 1-131, plates I-XXVII

Issued June 15, 1932

TABLE OF CONTENTS

THE HYPODERMATACEAE OF CONIFERS

PREFATORY NOTE

The Hypodermataceae of conifers, the so-called "needle cast fungi" are widely distributed, occurring wherever their hosts are to be found. They are frequently very abundant, easily recognizable by their dark, often glossy black fructifications; and at times they attract attention because of the extensive brown discoloration of the foliage ravaged by certain species. From time to time individual species have been the subjects of detached investigations, usually sequent to epidemics in forest or nursery. Notable contributions to our knowledge of these fungi have been made by such botanists and foresters as Hartig (1874), von Tubeuf (1901) and Haack (1911) in Germany; Lagerberg (1910) in Sweden; Hagem (1926) in Norway; von Höhnel (1917) in Austria; Mer (1913) in France; Skoric (1923) in Jugoslavia; Weir (1916) and Dearness (1924) in America. On the other hand no one has advanced research in the group beyond a very limited horizon or beyond local areas, and nothing approaching a monograph on the group has ever appeared.

A survey of the subject indicates that investigative effort can profitably be expended in several directions, but particularly in relation to the taxonomy of the group, the working out of life histories, the study of their distribution, the evaluation of their relative pathogenic importance, and a determination of means of control.

The work presented in this paper deals mainly with taxonomy and life histories. With reference to the first point it may be noted that up to the present about twenty-four valid species have been described and named; but a survey of the literature reveals the fact that there exist discrepancies and misunderstandings with regard to many of them. A study of a wide range of material has brought to light an equal number of new species, most of them on conifers in America. As to life histories we have before us an almost virgin field. Such studies have been made by Haack, Rostrup, Mayr and Prantl

on *Lophodermium pinastri,* by Mer on *Hypodermella nervisequia,* and by Weir on *Hypoderma deformans.* To these the writer has added successful studies on *Hypoderma Desmazierii, Hypodermella concolor, Hypodermella Laricis, Hypodermella nervata* and *Bifusella Faullii.* Incidentally some additions have been made to the topics of distribution, pathogenicity and control.

The investigations reported here were begun in the University of Toronto, and continued for the last three years at the Arnold Arboretum in Harvard University. Field studies under the auspices of the University of Toronto and the Ontario Forestry Branch were carried out for several summers in the Timagami Forest Reserve, Ontario; and opportunities for collecting in Massachusetts, California, Nevada, Oregon, Idaho and British Columbia have also been made possible through generous aid from the Arnold Arboretum. Access has been freely given to collections in the Farlow Herbarium, the Herbarium of the University of Toronto, the Herbarium of the Office of Forest Pathology in San Francisco, and to the private collections of Professor J. S. Boyce and Professor J. H. Faull. Professor Boyce, Professor Faull, Dr. John Dearness, Professor J. J. Davis, Dr. L. E. Miles, and Dr. René Maire have very generously provided type materials. I am also under obligations to Professor Oakes Ames, Mr. E. J. Zavitz, Professor Wm. H. Weston, Jr., Dr. C. W. Dodge, Mr. Alfred Rehder, Dr. E. P. Meinecke, Mr. L. N. Goodding, Dr. Ivar Jørstad, Dr. L. O. Overholts, Dr. Perley Spaulding, Mr. P. V. Siggers, Mr. W. H. Kerr and many others for contributions of material, information or other help. I desire especially to express grateful recognition to Professor Faull, who suggested the subject and who has followed my work throughout with sustained interest.

PART I. TAXONOMY

INTRODUCTION

GENERAL CHARACTERS OF HYPODERMATACEAE

According to the system of classification at present generally accepted, the Hypodermataceae belong to the ascomycetous Order Hysteriales. They share, in common with other members of the Order, a distinguishing type of fructification, a so-called hysterothecium. Hysterothecia are more or less elongated perithecia which open at maturity to permit discharge of the spores by means of a medially located, longitudinal fissure; in shape they vary according to the species, from subcircular or elliptical to linear, and they may be convex, often mussel-like, or flat or depressed.

In the Hypodermataceae the hysterothecia are embedded in the substratum to which they are firmly united above to form a clypeus or shield. In some species the clypeus possesses a narrow, differentiated area analogous to the annulus of a moss capsule, extending medially and longitudinally along the full length of the hysterothecium; this area predetermines the position of the slit. For want of a term to designate this area I suggest the name *slit band*. Other species show in advance of maturity no visible evidence of a line of dehiscence. At maturity in wet weather the hysterothecium is slit open lengthwise exposing the disc of the hymenium. The hymenium may be flat or concave and is composed of numerous asci and in most species paraphyses, both structures arising from a basal layer of loose or compact plectenchyma. Lateral extensions of the basal layer constitute the hysterothecial wall. In some cases the marginal paraphyses become modified into periphyses which, in turn, merge into the hysterothecial wall.

Several types of conidial fructifications have been assumed to be constituents of the life cycles of various of the Hypodermataceae. Those, however, for which the associations have been experimentally established are of simple pycnidial types belonging to or closely related to the genera *Leptostroma* and *Hypodermina*. The pycnidium is a flat or convex cushion of hyphae from which arise simple upright conidiophores.

From the conidiophores are abstricted minute, bacillar conidia the functions of which remain to be demonstrated.

HISTORY OF CLASSIFICATION

As the history of the classification of the Hysteriales has been ably summarized by Bisby (1921) I shall limit myself to a brief outline only, for the purpose of indicating the more important trends in the taxonomic disposition of the Order. In harmony with the scope of my investigations I shall follow the history for the main part of those genera the species of which are found on conifers.

The earliest records of Hysteriaceous fungi are to be sought in the literature dealing with the Lichen floras, and these extend back into the early half of the eighteenth century. It was not until a considerably later date (1784) that Tode founded *Hysterium,* the first genus created for Hysteriaceous fungi. Tode added other species to the genus in 1791 and Persoon (1801) revised and systematized them up to his time. Then De Candolle (1805) separated those species with subepidermal ascocarps under the generic name *Hypoderma,* leaving in the genus *Hysterium* those with superficial ascocarps. In the new genus he placed five species at first, but later added several others. Chevallier next (1822) transferred three species of De Candolle's *Hypoderma* to a proposed genus *Lophoderma,* a genus which was based upon a character now recognized as of doubtful value.

Fries (1823), however, did not accept *Hypoderma* DC. and *Lophoderma* Chev. and returned the species of both of these genera to *Hysterium;* this genus he placed together with *Glonium, Actidium, Rhytisma, Phacidium* and *Excipula* in the Phacidiacei, under the order Myelomyci of the Pyrenomycetes. Then in a subsequent publication (1835) he proposed the name Discomycetes to embrace all Ascomycetes with hymenia that are exposed at maturity, and transferred the Phacidiacei to this class. Chevallier (1826) was the first to suggest a separation of the Hysteriaceous fungi from the Phacidiaceous and in his scheme the class Cheilomycei with the Hysterineae was given equal ranking with the class Phacomyci containing the order Rhytismaceae. The genus *Lophodermium* was created by Chevallier to replace *Lophoderma* and it

included also among its species most of those originally placed by De Candolle under *Hypoderma*. *Lophodermium arundinaceum* Schrader ex Chev., the first species listed by Chevallier, is now recognized as the type of the genus. Corda (1842) established the order Hysteriaceae and included in it the families Stegiaceae, Hysteriaceae, Gloniaceae, Cliostomei and Phacidiacei. The inclusion of the Phacideii under the Hysteriaceae was a reversal of the taxonomic sequence maintained by Fries and other workers who had included the Hysteriaceous genera under the Phacidiacei.

It should be pointed out that determinations of genera thus far were still almost entirely based on superficial, structural characters of the hysterothecium and as a consequence the taxonomic groups often contained genera differing widely in their microscopic features. Thus Chevallier's order Hysterineae included *Lophium, Hysterium, Lophodermium* and *Schizoderma;* and the order Rhytismaceae contained the genera *Leptostroma, Actinothyrium, Phacidium, Eustegia, Rhytisma* and *Phoma*. As soon as microscopic characters of the fungi were studied comparatively they began to be used taxonomically. This brings us to Corda who, in 1842, made use of spore characters to some extent in classification of the fungi. De Notaris (1847) developed further the use of spore characters, especially color, shape and septation, as a taxonomic basis in his classification of the Hysteriacei. He divided the Hysteriacei primarily on a spore color basis into the Phaeosporii and the Hyalosporii. Then under those sections the genera were defined by long descriptive phrases without indicating clearly the relative value of the secondary diagnostic characters.

De Notaris was responsible for the revival of De Candolle's genus *Hypoderma,* but his definition of the genus was so broad that it served to include a miscellany of innate erumpent forms which could not be made to fit into other known related genera. He did, however, define clearly the genus *Lophodermium* as possessing filiform spores. And so he transferred back to the elastic *Hypoderma* those of Chevallier's species of *Lophodermium* the spores of which were not filiform. De Notaris considered the Hysteriacei to be a distinct group under the Pyrenomycetes.

The next important advance was Duby's (1861) memoir on

the Hysterineae, which he designated as a distinct group under the Pyrenomycetes, apparently following De Notaris in this respect. His primary separation of the Hysterineae into the Lophiees and Hysteriees was based on observations of external characters, the Lophiees possessing erect, laterally compressed receptacles, the Hysteriees, on the other hand, with applanate receptacles. Secondary separation was based on the type of dehiscence of the asci, a faulty distinction interpreted from incomplete observations. A significant feature of Duby's work was the accuracy with which he delimited his species and genera. His shortcomings appear to have been due to unsound interpretations and not to the quality of his observations. The latter were good but were limited by the inadequacy of the microscopic equipment of his time.

The use of spore characters as employed by Corda, De Notaris and Duby in the classification of the Hysteriales was not generally accepted at first. The influence of Fries was still strong and continued to be felt through the works of Rabenhorst, Berkeley, Fuckel and the earlier writings of Cooke and Saccardo. The importance of spore characters, however, eventually gained recognition. Thus we find Saccardo swinging over to a spore scheme of classification. Saccardo divided the Hysteriales, which he placed under the Pyrenomycetes, into five sections, Hyalosporae, Didymosporae, Phragmosporae, Scolecosporae and Dictyosporae. Spegazzini carried Saccardo's scheme further and made four sections, Aplosporae, Didymosporae, Phragmosporae and Dictyosporae, each of which was divided again on spore color into Hyalosporae and Phaeosporae. The final elaboration in this direction was that of Saccardo (1883) who established nine sections defined by shape, septation and color of spores.

It remained to Rehm to elaborate the main lines of a classification of the Hysteriales, which, except for minor details, has remained current to the present time. In 1886 he published a revision of the Hysteriales in Duby's herbarium under the name Hysteriaceae Corda, and in 1887 a classification in Rabenhorst's Kryptogamen-Flora. He regarded the Hysteriales as a distinct group lying between the Discomycetes and the Pyrenomycetes, though nearer the Pyrenomycetes. He included within its limits three families, namely, Hysterineae,

Hypodermieae and Dichaenaceae. The Pseudohysteriaceae, with the family Acrospermaceae, was added as an appendix to the group.

Lindau's treatment of the Hysteriales as found in Engler and Prantl's Pflanzenfamilien (1896) followed essentially that of Rehm, but under the name Hysteriineae. Lindau divided his Hysteriineae into five families, Hypodermataceae (Hypodermieae Rehm), Dichaenaceae, Ostropaceae, Hysteriaceae (Hysterineae Rehm) and the Acrospermaceae. The superficial or immersed position of the hysterothecium in the substratum was employed as the primary basis for diagnosis of the families; attachment of clypeus to substratum, consistency of hysterothecium and color of hysterothecium were used secondarily. Within the Hypodermataceae spore characters such as shape, septation and color were employed to delimit the genera.

For the sake of completeness mention should be made of von Höhnel's radical proposals with respect to the taxonomy of the Hysteriales. Von Höhnel (1918) combined the Hysteriaceae and the Lophiostomataceae into a new order, the Hysterostomeae, placed under the Pyrenomycetes. The majority of the Hypodermataceae and the Phacidiaceae together with a few other genera he united (1917[1]) into the order Phacidiales v. H. He then redivided this order into six families founded primarily upon the position of the hysterothecium on or within the substratum, as follows:

I. Schizothyrieae v. H. On the cuticle.
II. Leptopeltineae v. H. On the epidermis under the cuticle (subcuticular).
III. Dermopeltineae v. H. In the epidermis (intraepidermal).
IV. Phacidiaceae v. H. (non Auct.). Under the epidermis (subepidermal) on leaves and stems and one genus breaking out from surface of naked wood.
V. Phacidiostromaceae v. H. Occupying whole leaf thickness, causing deformation of epidermis, or in and under epidermis of stems extending deeply into the tissues and deforming epidermal walls.
VI. Cryptomyceteae v. H. Under the periderm or on bare wood.

Secondary characters used by v. Höhnel vary slightly from

group to group but appear to rank in importance as follows: absence or presence of stroma, spore characters (shape, septation, color), ascocarp characters and ascus characters. He made most consistent use of the presence or absence of a stroma. Incidentally, it is to be noted that a stromatic distinction is extremely difficult of use from a taxonomic viewpoint, especially in a group in which developmental studies are almost completely lacking. Von Höhnel's definition of a stroma was so broad that it included not only a matrix on or within which a fructification was formed but also such structures as the dark elongated sclerotic crusts which develop in association with certain ascocarps, e. g. in *Bifusella linearis*.

In a recent publication Hilitzer (1929) has monographed the Hysteriales of Bohemia. It is a noteworthy fact that he has followed the older, more conservative classification of Lindau. His researches on the conidial stages of the Hysteriales have been especially fruitful and have enabled him to point out clear-cut distinctions between the Hypodermataceae and the Hysteriaceae on the basis of conidial characters. But his taxonomic generalizations based upon studies of the morphological structure of the hysterothecia cannot be wholly supported by my own researches. Hilitzer considers the Hysteriales to represent an order which has developed parallel to the Sphaeriales which is a new idea in the phylogeny of the order.

In the present investigation the writer has preferred to follow the more conservative classification of Lindau, recognizing, however, that the group is still more or less heterogeneous and in need of comparative study.

A history of the disposition of the species of the Hypodermataceae which occur on coniferous needles is, in general, a recapitulation of the history of the Hysteriales. The first species recorded on conifers was *Lophodermium pinastri*, independently described in 1799 by Schrader and Wibel under the names *Hysterium pinastri* Schrad. and *Hysterium limitatum* Wibel. Schrader illustrated *H. pinastri* on *Pinus sylvestris* and reported the species also on *Pinus Abies*. De Candolle (1805) transferred *H. pinastri* to his genus Hypoderma and later added another conifer-inhabiting species *Hypoderma nervisequium*. The latter species was transferred to the genus

Lophoderma of Chevallier (1822), but Fries (1823) recognized neither *Hypoderma* nor *Lophoderma* and so both species were returned to the genus *Hysterium*. Later Chevallier (1826) established the genus *Lophodermium* and included among its species *Lophodermium nervisequum* and *Lophodermium pinastri*. De Notaris (1847) reestablished the genus Hypoderma in which *Hypoderma Desmazierii* Duby (1861) became the first species named on conifer needles. During this period and for the following thirty years the species of Hypodermataceae occurring on conifer needles were variously placed, depending upon whether the writer was following Fries or De Notaris and Duby, in the genera *Hysterium, Hypoderma* and *Lophodermium*. Later, Tubeuf (1895) founded the genus *Hypodermella* based on *Hypodermella Laricis* which was distinguished from the other genera by its 4-spored asci and "inverted tear-shaped" spores. Lagerberg (1910) called attention to the fact that *H. Laricis* and *Hypodermella sulcigena* frequently possessed 8-spored asci in addition to 4-spored, and thereupon added two other species with clavate spores to the genus. More recently von Höhnel (1917[5]) established the genus *Bifusella* for *Hypoderma lineare* (Peck) Thümen, characterized by doubly clavate spores with a narrow constricted portion in the middle. In the same year von Höhnel (1917[1]) proposed three other genera—*Lophodermina, Lophodermellina* and *Lophodermella*—none of which has received general acceptance. In this paper the genus *Elytroderma* is suggested for Weir's *Hypoderma deformans,* a species with strikingly elongated, fusiform, two-celled spores.

BASES FOR CLASSIFICATION AND THEIR MERITS

The characters used in classification of the Hysteriales fall in general under those of spores, asci, hysterothecia and pycnidia.

Spore characters have long been recognized as of fundamental importance and because of their constancy have been employed in the classification of many groups of fungi. The outstanding features of taxonomic value in connection with the spores of the Hypodermataceae are shape and septation; the family is divided into genera largely on these bases. Relative spore length is of some importance, but caution must be

exercised in making use of spore width. The gelatinous sheath is a constant feature of the ascospores of certain genera but has rarely been given much attention, probably because it is not so evident in dried material. To these may be added a feature not heretofore used, but certainly of diagnostic value, namely, the form of the germ tubes.

Commenting further on the matter of lineal measurements it is to be noted that in the Hypodermataceae ascospore characters show a wide range of variation during development. Even after the opening of the hysterothecium there is a period during which the spores increase markedly in size. Furthermore, the time of preservation of herbarium material influences the amount of shrinkage of spores. *In Hypoderma, Hypodermella* and *Bifusella* measurements of spore width are extremely variable. In certain species the shrinkage is often very nearly equal to one-half the spore thickness. Spore length, on the other hand, is a relatively stable character. On drying there is very little shrinkage in length and measurements of spores are fairly consistent, providing, of course, that spores of approximately the same age are measured. Due to the fact that a hysterothecium at maturity contains asci in all stages of development, the writer has attempted whenever possible to obtain measurements from spores discharged on a cover glass from freshly collected material.

Ascus measurements appear to be rather variable even within a single species, due chiefly to the fact that at maturity the ascus undergoes a rapid elongation. The range of measurements is usually so great that there is a wide overlapping between species. Stalked asci are characteristic of certain species but the character has not been demonstrated as worthy of generic value.

Hysterothecial characters are not sharply delimited for the different species. Much more research on this topic is necessary before any broad generalizations can be made. The relation of the hysterothecium to the substratum and consistency of the hysterothecium have been employed by Lindau to separate the Hysteriales into families. Saccardo used hysterothecial characters only for generic separations. Von Höhnel based his classification of the Phacidiales fundamentally on hysterothecial characters, using position of the hysterothecium

in the substratum and presence or absence of a stroma as of first importance. The presence or absence of a slit band was used for the separation of certain genera by von Höhnel. The nature of the slit band is very striking in certain of the *Lophodermium* species but whether it is of more than specific value is questionable at present. Dearness found well marked gradations in the degree of development of the clypeus within a single species. But in the species studied by Dearness the clypeus is almost colorless and at maturity might easily appear to be lacking as claimed. Color of the hysterothecium is a fairly constant character for each species and is dependent on the color and extent of the clypeus. In deep seated species such as *Hypodermella sulcigena* the clypeus is thin and almost colorless while in subcuticular species like *Hypodermella Laricis* the clypeus is thick and dark colored.

The structural and developmental characters of the imperfect stages of the Hysteriales have only recently begun to receive the attention which they have merited. Hilitzer (1929) and Lohman (1930) have independently revealed many new findings concerning the conidial stages of the Hysteriaceae. In this study the writer has pointed out the value of the pycnidia in separating the "nervisequious" species of Hypodermataceae occuring on *Abies* from one another, shape, color and position of the pycnidia being notably constant for each species.

KEY TO GENERA OF HYPODERMATACEAE ON CONIFERS

A. Ascospores not filiform and rarely fasciculate.
  B. Ascospores one-celled.
    C. Ascospores fusiform or rod-shaped, less than one-fourth of the length of the ascus .....HYPODERMA.
    C. Ascospores clavate.
      D. Ascospores clavate at both ends, the halves joined by a narrow isthmus, less than one-half of the length of the ascus .....BIFUSELLA.
      D. Ascospores clavate at upper end, tapering acutely towards base, one-fourth to three-fourths of the length of the ascus .....HYPODERMELLA.
  B. Ascospores two-celled, broadly fusiform .....ELYTRODERMA.
A. Ascospores uniformly filiform, fasciculate .....LOPHODERMIUM.

BIFUSELLA von Höhnel, in Ann. Myc. **15**:318 (1917).

Hysterothecia innate erumpent, black or dark brown, short elliptical to linear, opening by a longitudinal slit, more or less superficial or extending deeply into substratum, hymenium applanate or concave. Asci broadly clavate or subcylindric, 8-spored, rounded or truncate at apex. Paraphyses simple, filiform, sometimes wanting. Ascospores rounded at both ends, constricted in the middle, unicellular, hyaline, about one-third of the length of the ascus, surrounded by a conspicuous gelatinous sheath. Pycnidia simple, conidiophore layer applanate, conidia minute, bacillar. Type species: *Bifusella linearis* von Höhnel.

KEY TO SPECIES OF BIFUSELLA

a. Paraphyses wanting; on Pinus .....1. *B. linearis*
a. Paraphyses present...b.
  b. Hysterothecia "nervisequious" on lower surface of needle; on Abies...c.
    c. Pycnidia in two rows, one on each wing of upper surface of needle .....2. *B. Abietis*
    c. Pycnidia effused along middle of upper surface of needle 3. *B. Faullii*
  b. Hysterothecia scattered, not "nervisequious"...d.
    d. Hysterothecia broader than distance between two adjacent stomatal lines; on Picea .....4. *B. crepidiformis*
    d. Hysterothecia narrower than distance between two adjacent stomatal lines; on Pinus .....5. *B. striiformis*

1. **Bifusella linearis** (Peck) v. Höhnel in Ann. Myc. **15**: 318 (1917).

Hypodermium effusum Schweinitz, Syn. Am. Bor. n. 2956 (1822).
Rhytisma lineare Peck in Ann. Rep. N. Y. St. Mus. Nat. Hist. **25**(1871):100 (1873).
Hypoderma lineare Thümen, Diag. M. U. Cent. x-xii. 12 (1878).
Lophodermium lineare Ellis & Everhart, N. Am. Pyrenomyc. 721 (1892).

Hysterothecia variable in length, shining black, frequently associated with extensive black sterile sclerotic crusts, 0.43-0.90 mm. wide, opening by a longitudinal slit; hysterothecia in cross sectional view subcuticular, 0.27-0.32 mm. deep (open); basal plectenchyma scanty, 5-10 μ thick, extending laterally

up sides of hysterothecium; pseudoparenchymatous covering layer 30-35 μ thick, tapering in thickness gradually towards the edges. Asci clavate at maturity, frequently more or less stipitate, 8-spored, 130-190 x 19-28 μ. Ascospores double spindle-shaped, constricted at the middle into a narrow isthmus 1-2 μ thick (thinner in dried herbarium material), hyaline, 41-60 x 5-7 μ (3-4 μ thick in dried material), with a gelatinuous sheath 2.0-4.5 μ thick. Aparaphysate.

On Abietineae. *Pinus Strobus* L.: Maine, Massachusetts, Minnesota, New Hampshire, New York, North Carolina, Pennsylvania, Wisconsin.—*Pinus monticola* Douglas ex Lamb.: Idaho, Washington, British Columbia.

Type Locality: "Guilderland, Greenbush, and Sandlake", New York, on *P. Strobus*.

Distribution: Maine to North Carolina and west to Washington and southern British Columbia.

Illustrations: 25th Ann. Rep. N. Y. St. Mus. Nat. Hist. 1871: pl. 1, fig. 24-26 (1873).—Phytopath. 3: 138, fig. 9, 10 (1913).—Mycologia 16: pl. 17, fig. 2-6 (1924).

Exsiccati: Thümen, Myc. Univ. 1073.

Other Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Pinus monticola,* 4, Priest River, Idaho, coll. G. D. Darker.—On *Pinus Strobus,* 814, Hamilton, Mass., coll. G. D. Darker.

Herbarium J. S. Boyce. On *P. monticola*: 1052, Sandpoint, Ida.; 1258, Upper Priest Lake, Ida.; 1257, Willard, Wash.; 1259, Red Mountain, Skamania Co., Wash.; 1671, Lake Crescent, Clallam Co., Wash.; 1260, Daisy Lake, B. C.; 1724, Beaton, B. C.—On *P. Strobus*: 1735, Boothbay Harbor, Me., coll. H. G. Lachmund; 1624, Wyeville, Wisc., coll. J. J. Davis; 1511, Biltmore, N. C., coll. G. G. Hedgcock.

Herbarium L. O. Overholts. On *P. Strobus*: 7507, Stone Valley, Huntingdon Co., Pa.; 9249, Laurel Run, Huntingdon Co., Pa.; 9310, Lamar, Clinton Co., Pa.

Herbarium G. D. Darker. On *P. Strobus*: 3550, near Old Orchard Beach, Me.; 3505, Weirs, N. H.; 3381, Hamilton, Mass.

Bifusella linearis has been described and illustrated by both Peck and Overholts (1924), but the only critical taxonomic study of the species was that of von Höhnel (1917[5]). Overholts described the asci as having sometimes less than the usual complement of eight spores. This condition has never been observed by the writer in *B. linearis*. Von Höhnel was the first worker to call attention to the diagnostic value of the

spores of *Bifusella*. The *Bifusella* type is an easily recognized concept, and in my judgment it is of generic rank.

Bifusella linearis is clearly set apart from the other conifer inhabiting species of *Bifusella* by its lack of paraphyses, by its subcuticular hysterothecia and by the effused stromatic layers of sterile tissue associated with the hysterothecia.

The parasitism of *Bifusella linearis* has never been studied, but under moist conditions there appears to be no question of its ability to cause a killing and defoliation of the needles of the white pines. As the defoliation is limited to needles two or three years old it cannot be regarded as a devastating pathogen.

2. **Bifusella Abietis** Dearness in Mycologia, 18:239 (1926).

Hysterothecia continuous, occasionally interrupted, extending along the lower median face of the needles, intraepidermal in the middle but becoming subepidermal toward the margins, opening longitudinally; lips inconspicuous, dark colored; hysterothecia in cross section 420-455 μ in width x 210-280 μ in depth, basal layer of compact plectenchyma 30-35 μ thick continuing up the sides of the hysterothecia in a narrow band, covering layer of epidermis and narrow band of dark pseudoparenchyma together about 30-35 μ thick, hymenial layer 120-160 μ thick. Asci clavate, thin-walled, rounded at tip, 8-spored, 28-30 x 115-160 μ. Paraphyses filiform, 110-120 μ long, hyaline, about 0.5-1.0 μ thick, surrounded by a thin gelatinous sheath. Spores double fusiform, with a narrow connecting isthmus, hyaline, 4-6 x 35-45 μ, with a gelatinous sheath about 5-7 μ thick. Pycnidia epiphyllous, intraepidermal, concolorous with leaf surface after maturity, extending in two rows along the wings of the needles, 140-240 μ in width.

On Abietineae. *Abies lasiocarpa* (Hook.) Nutt., Colorado, Idaho.—*Abies lasiocarpa* var. *arizonica* (Merriam) Lemm., New Mexico.

Type Locality: Bonanza, Custer Co., Idaho, on *A. lasiocarpa*.

Distribution: Idaho to New Mexico.

Specimens Examined. Herbarium J. S. Boyce. On *Abies lasiocarpa*: 1701, Bonanza, Custer Co., Idaho, coll. G. G. Hedgcock; 1702, Aspen, Pitkin Co., Colo., coll. J. V. Keefe; 1703, Uncompaghre Nat. Forest, Ouray Co., Colo., coll. G. G. Hedgcock.

Bifusella Abietis is most closely allied to *Bifusella Faullii*

which occurs on *Abies balsamea* in northeastern North America. Both species are distinguished from other species of *Bifusella* by the "nervisequious" character of their hysterothecia. They are readily separated from one another by the fact that in *B. Abietis* the pycnidia form two lines, one along each side of the sinus on the upper surface of the needles, while in *B. Faullii,* they are confined more closely to the midrib as sinuous, more or less effused cushions. Two other "nervisequious" Hypodermataceae, *Hypoderma robustum* and *Hypodermella mirabilis* also have the same type of pycnidial fructification as *B. Abietis*. Positive identification cannot be made in the field with assurance, although so far as is known at present the ranges of the three fungi do not overlap.

3. **Bifusella Faullii,** sp. nov.

Hysterotheciis praecipue hypophyllis nervisequis linearibus aut interdum interruptis circiter 0.20-0.32 mm. latitudine, labiis longitudinali fissura late aperientibus; disco lurido; hysterotheciis in transversali sectione in medio intraepidermalibus, sed ad marginem subepidermalibus, 0.15-0.20 mm. profundis; basilari plectenchymate tenellula compactaque, 25-35 μ crassa in perithecii centro; tegente strato epidermalis parietis plectenchymatisque 30-40 μ crasso, paucis cellis pseudoparenchymatosis et pallide brunneis; hymenio 90-135 μ crasso. Ascis clavatis octosporis 85-135 x 19-25 μ. Paraphysibus filiformibus directis 125 μ longis circiter 1 μ crassis. Ascosporis bifusiformibus cum parva constrictione hyalinis 45-55 x 5-6 μ muco 3-5 μ crasso involutis. Pycnidiis epiphyllis intraepidermalibus in duplici aut simplici ordine sinuosis aut daedaleis, variabilibus latitudine; strato conidiophororum 15-23 μ crasso, conidiophoris simplicibus, 12-20 μ longis. Conidiis hyalinis ellipticis 3.0-3.5 x 1.0-1.2 μ.

In foliis *Abietis balsameae* (L.) Mill., Lake Timagami, Ontario, mense Iulio, 1924, Arnold Arboretum, Pathological Herbarium, 811, G. D. Parker legit.

Hysterothecia chiefly hypophyllous, rarely occurring on the upper surface, on needles two years old or older, extending along the middle of the leaf, linear or interrupted, about 0.20-0.32 mm. in width, opening widely by a longitudinal fissure; disc pale yellow; hysterothecia in cross section intraepidermal

in middle but becoming subepidermal at edges, 0.15-0.20 mm. deep; basal plectenchyma very delicate and compact, 25-35 μ thick in centre, becoming narrower towards edges and continuing in a thin layer up sides of hysterothecium; covering layer of epidermal wall and plectenchyma 30-40 μ thick, plectenchyma of same appearance as basal layer except for a few cells adjoining the epidermis which have become light brown in color and pseudoparenchymatous; hymenium 90-135 μ thick. Asci clavate, truncate at tip when young, 8-spored, 85-135 x 19-25 μ. Paraphyses filiform, straight, 125 μ long, about 1 μ in width. Ascospores double fusiform with a slight constriction, hyaline, 45-55 x 5-6 μ, surrounded by a gelatinous sheath 3-5 μ in thickness (measurements from fresh material). Pycnidia epiphyllous on one year old needles, intraepidermal, extending the length of the leaf, in a double or single row, sinuous or labyrinthine in appearance, extremely variable in width; conidiophore layer 15-23 μ thick, conidiophores simple, tapering rather gradually toward the tip, about 12-20 μ long. Conidia hyaline, elliptical, 3.0-3.5 x 1.0-1.2 μ, exuding from the pycnidia in effused masses or rarely in long tendrils.

On Abietineae. *Abies balsamea* (L.) Mill.: Michigan, New Hampshire; Nova Scotia, Ontario, Quebec.

Type Locality: Lake Timagami, Ontario, on *A. balsamea,* July, 1924, Arnold Arboretum, Pathological Herbarium, 811, coll. G. D. Darker.

Distribution: Northern Ontario to Nova Scotia and south into New Hampshire.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Abies balsamea,* 811 (Type), Bear Id., Lake Timagami, Ont., coll. G. D. Darker.

Herbarium J. S. Boyce. On *A. balsamea*: 1835 (in part), near Smyrna Mills, Aroostook Co., Me.; 1506, Blue Brook Ranger Station, White Mts., N. H., coll. G. G. Hedgcock.

Herbarium J. H. Faull. On *A. balsamea*: 9274, 9275 (in part), Liscomb Park, Guysboro Co., N. S.; 9242, near Card Lake, Lunenburg Co., N. S.; 8684 (in part), 8773 (in part), 9071 (in part), Claude Lake, Gaspé Co., Que.; 8650, Trail to Claude Lake, Gaspé Co., Que.; 8712, McNab Mt., Shickshock Mts., Gaspé Co., Que.; 4768, Lake Kenogami, Que.; 4848, 5064, 5597 (in part), 6522 (in part), 6524, 6545, 6555, Lake Timagami, Ontario.

University of Michigan Herbarium. On *A. balsamea*: Raspberry Id., near Isle Royale, Mich., coll. A. Povah.

Herbarium G. D. Darker. On *A. balsamea*: 1064, Algonquin Park,

Ont., coll. J. H. Faull; 1108, 1111, 1120, 1122, 1149, 1216, 1256, 1291, 1300, 1312, 1329, 1441, 1495, 1520, 1535, 1544, 1625, 1696, 1758, 1759, 2048, 2111, 2142, 2219, Lake Timagami, Ont.; 3592, Mt. Washington, N. H., coll. J. H. Faull.

Bifusella Faullii is the commonest and the most destructive of the Hypodermataceae on *Abies balsamea* in eastern North America. It is most injurious to juvenile plants but also attacks older trees in close stands. Small seedlings a few inches in height suffer severely from its attacks. Parasitism of *B. Faullii* has never been satisfactorily demonstrated, however, although a number of experiments performed by the writer yielded a few doubtfully successful infections.

In Northern Ontario ascospores are discharged chiefly during the month of July and are carried to the young foliage. There is no sign of disease on the Balsam during the first season but in the following spring the leaves change color gradually until about the first of July, at which time all of the one year old needles have become ochraceous tawny (Ridgway, 1912) or ochraceous orange (R). The needles then gradually become patchy with lighter colored areas until the wings of the needles have assumed an ochraceous buff (R) color leaving only the pycnidia ochraceous tawny. At this time a cross section through the leaf reveals the fact that the parenchyma cells are tightly filled with starch grains. The pycnidia produce a great abundance of minute bacillar spores which become effused over the upper leaf surface during damp weather. In a moist chamber the conidia are sometimes given off in long coiled tendrils. Shortly after conidial discharge the hysterothecia begin to form on the lower surfaces of the needles. By the time of their maturity (July of the following year) the lower surfaces of the diseased needles have turned an ochraceous salmon (R) and the upper surfaces cartridge buff (R). The mature hysterothecia are dusky brown (R) and the exposed discs orange buff (R). Mature hysterothecia and pycnidia are to be found at approximately the same time; but the new pycnidia are on one year old needles and the hysterothecia are on needles that are two years old or older.

Bifusella Faullii is readily distinguished from all other "nervisequious" species on *Abies* by its sinuous, labyrinthine, effused pycnidia which follow the sinus on the upper surface

of the needle. *Bifusella Faullii* can be distinguished from *B. Abietis,* the most closely related species, by the ascospores. Those of *B. Faullii* never show the thin "wasplike" constriction characteristic of *B. Abietis.*

Ascospore germination in water is very striking for this species. The ascospore becomes two-celled and then sends out a short germ tube which branches and rebranches at the tip forming a peculiar appressorium-like palmate disc. Occasionally a short germ tube grows out from the expanded disc and forms a clavate swelling at its tip.

4. **Bifusella crepidiformis,** sp. nov.

Hysterotheciis media longitudine 0.5-3.0 x 0.30-0.63 mm., nigris conspicuis hypophyllis; hysterotheciis in transversali sectione intraepidermalibus 0.19-0.32 mm. profundis; basilari plectenchymate candido 20-40 μ crasso; tegente strato atri pseudoparenchymatis parietisque epidermalis 40-63 μ crasso, hymenio 105-165 μ crasso. Ascis clavatis truncatis 145-165 x 24-28 μ. Paraphysibus filiformibus circiter 1 μ latis et 140 μ longis directis parum afflatis in apicibus. Ascosporis bifusiformibus in medio parum constrictis 60-75 x 8.0-8.5 μ, muco 3.5-4.5 μ crasso involutis.

In affixis foliis *Piceae glaucae* (Moench) Voss, Lake Timagami, Ontario, mense Augusto, 1925, Arnold Arboretum, Pathological Herbarium, 812, G. D. Darker legit.

Hysterothecia of medium length, 0.5-3.0 x 0.30-0.63 mm., black, conspicuous, hypophyllous, opening longitudinally; hysterothecia in cross section intraepidermal, 0.19-0.32 mm. deep; basal plectenchyma light colored, 20-40 μ thick; covering layer of dark colored pseudoparenchyma and epidermal wall 40-63 μ thick, hymenium 105-165 μ thick. Asci at maturity clavate, truncate, 145-165 x 24-28 μ. Paraphyses filiform, narrow, about 1 μ wide, 140 μ long, straight, slightly swollen at the tips. Ascospores double fusiform, slightly constricted in middle, 60-75 x 8.0-8.5 μ (measurements from fresh material), gelatinous sheath 3.5-4.5 μ thick.

On Abietineae. *Picea glauca* (Moench.) Voss, Ontario.—*Picea mariana* (Mill.) BSP., Ontario.

Type Locality: Lake Timagami, Ontario on *P. glauca,* August, 1925, Arnold Arboretum, Pathological Herbarium, 812, coll. G. D. Darker.

DISTRIBUTION: known only from Northern Ontario.

SPECIMENS EXAMINED. Arnold Arboretum, Pathological Herbarium; on *Picea glauca,* 812 (Type), Lake Timagami, Ont., coll. G. D. Darker.

Herbarium J. H. Faull. On *Picea mariana,* 5569, Lake Timagami, Ont.

Herbarium G. D. Darker. On *P. glauca*: 1565, 2306, Lake Timagami, Ont.—On *P. mariana*: 1079, 1093, 1114, 1318, 1371, 1377, 1437, 1472, 1510, 1533, 1580, 1827, 2098, 2221, Lake Timagami, Ont.; 1125, Lake Wasacsinagama, Timagami Forest Reserve, Ont.

Black Spruce (*Picea mariana*) growing in dense stands is often heavily infested by this species, but the White Spruce (*P. glauca*) is more rarely attacked. *Bifusella crepidiformis* has never been artificially produced in infection experiments; it has, however, the appearance of being a weak parasite. The diseased needles do not fall off but remain for several years after the hysterothecia have matured.

Bifusella crepidiformis externally resembles *Lophodermium macrosporum* and to a lesser extent *Lophodermium Piceae;* but its broad clavate asci and more or less constricted spores distinguish it at once from the other spruce-inhabiting species, the asci of which are almost cylindrical and contain filiform spores. Ascospore germination is somewhat similar to that of the other species of *Bifusella.* The short germ tubes form a lobed swelling at their tips and sometimes secondary tubes arise from the swellings.

5. **Bifusella striiformis,** sp. nov.

Hysterotheciis numerosis brevibus ellipticis usque elongatis linearibusque 0.15-0.30 x 0.48-8.00 mm. subepidermalibus, obscure vel lucide atris, longitudinali incisura secus stomatum lineas aperientibus; labiis exilibus atris; hysterotheciis ante aperiendum in transversali sectione visis fere forma triangulari, maturitate 0.18-0.25 mm. profundis; plectenchymatico basilari strato 7-10 μ crasso; tegente strato epidermidis 60-100 μ crasso in centro, 30-35 μ crasso ad margines versus, tegente strato atri pseudoparenchymatis 23-30 μ crasso in centro, 14-15 μ crasso ad margines versus; hymenio plano 100-130 μ crasso. Ascis clavatis abrupte in apicem rotundatum attenuatis octosporis 120-130 x 20-24 μ. Paraphysibus filiformibus interdum in apice leviter afflatis, circiter 1 μ crassis, usque 100 μ longis. Ascosporis bifusiformibus, interdum trifusiformibus

distincte constricti hyalinis 41-61 x 3-7 μ, muco 3-5 μ crasso involutis.

In foliis *Pini Torreyanae,* Golden Gate Park, San Francisco, California, mense Augusto, 1929, Arnold Arboretum, Pathological Herbarium, 659, G. D. Darker legit.

Hysterothecia numerous, mostly on the outer, abaxial surfaces of the needles, short, elliptical to elongated linear, 0.15-0.30 x 0.48-8.00 mm., subepidermal, dull to shining black, opening by a longitudinal slit along the stomatal lines; lips thin, dark; hysterothecia in cross sectional view roughly triangular in outline before opening, at maturity 0.18-0.25 mm. deep; plectenchymatous basal layer 7-10 μ thick; covering layer of epidermis 60-100 μ thick in centre and 30-35 μ thick towards margins, covering layer of dark pseudoparenchyma 23-30 μ thick in centre, 14-15 μ thick towards margins; hymenium at maturity rather uniform, flat, 100-130 μ thick. Asci clavate, tapering abruptly to a rounded apex, and gradually towards the base, 8-spored, 120-130 x 20-24 μ. Paraphyses filiform, sometimes slightly swollen at apex, about 1 μ in thickness, up to 100 μ long, about 6-septate. Ascospores double fusiform, sometimes triple fusiform in shape, with well marked constrictions, hyaline, 41-61 x 3-7 μ, with a gelatinous sheath 3-5 μ in thickness.

On Abietineae: *Pinus Pinaster* Ait., California.—*Pinus Sabiniana* Dougl., California.—*Pinus Torreyana* Carr., California.

Type Locality: Golden Gate Park, San Francisco, California on *P. Torreyana,* August 1929, Arnold Arboretum, Pathological Herbarium, 659, coll. G. D. Darker.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Pinus Pinaster*: 654, 663, 672, 680, San Francisco, Cal.—On *Pinus Sabiniana,* 676, Stanford University, Cal.—On *Pinus Torreyana,* 659 (Type), 662, San Francisco, Cal.

Bifusella striiformis was observed to be the cause of a needle casting on *Pinus Torreyana.* On the other hosts, however, although abundant, the fungus was chiefly confined to dead terminal portions of small branches. No evidence of parasitism was suggested by the latter. The numerous small hysterothecia arranged along the stomatal lines serve at once to distinguish this species with certainty in the field.

HYPODERMA De Candolle apud De Notaris in Giorn. Bot. Ital. **2**:35 (1847).

Hysterothecia dark, dull or shining black, mostly short elliptical, opening by a narrow longitudinal slit, hymenium flat, occasionally concave and deeply sunken in the substratum. Asci clavate to cylindric, 8-spored or with 4 spores frequently aborted. Paraphyses simple, filiform, sometimes wanting. Ascospores up to one-fourth of the length of the ascus, bacillar to fusiform, surrounded by a thick gelatinous sheath, hyaline, unicellular. Pycnidia simple, applanate, with minute bacillar or clavate conidia. Type species: *Hypoderma Rubi* (Persoon ex Fries) De Notaris.

KEY TO SPECIES OF HYPODERMA

a. Primordium of slit of hysterothecium obvious...b.
  b. Hysterothecia short elliptical; on Pinus ....6. *H. Desmazierii*
  b. Hysterothecia "nervisequious"; on Abies .....7. *H. robustum*
a. Primordium of slit of hysterothecium not obvious; on Pinus...c.
  c. Paraphyses present...d.
    d. Hysterothecia minute, brownish black, narrower than distance between two adjacent stomatal lines ...8. *H. pedatum*
    d. Hysterothecia conspicuous, shining black...e.
      e. Pycnidia inconspicuous, minute...f.
        f. Asci with eight functional spores .....9. *H. lethale*
        f. Asci with four functional spores ..10. *H. Hedgcockii*
      e. Pycnidia conspicuous, as large as hysterothecia 11. *H. saccatum*
  c. Paraphyses lacking .....12. *H. Pini*

6. **Hypoderma Desmazierii** Duby in Mém. Soc. Phys. Hist. Nat. Genève, **16**:42 (1861).

Lophodermium brachysporum Rostrup in Tidsskr. Skovbr. **6**:281 (1883).

Hypoderma brachysporum v. Tubeuf, Pflanzenkrankheiten durch kryptogame Parasiten verursacht, 247 (1895).

Hypoderma strobicola v. Tubeuf in Tubeuf & Smith, Diseases of plants induced by cryptogamic parasites, 233 (1897).

Lophodermium lineatum Smith & Ramsbottom in Trans. Brit. Myc. Soc. **6**:365 (1920).

Hypoderma Namyslowski Birula, Dabrowski & Krolikowski in Roczn. Nauk Roln. Lesnych, **20**:35 (1928).

Leptostroma strobicolum Hilitzer in Vědecké Spisy vyd. Českoslov. Akad. Zeméd. **3**:99 (1929).

Hysterothecia often in a more or less continuous row, chiefly along the outer abaxial surfaces of the needles, fre-

quently confluent, elliptical, opening by a narrow longitudinal fissure, 0.50-1.00 x 0.25-0.42 mm., with the black dome-shaped portion surrounded typically by a narrow grayish zone; hysterothecia in cross section 0.14-0.26 mm. deep, subepidermal except for a small subcuticular area in neighborhood of lips, lips bordered by a palisade-like row of papillate colorless cells; basal layer of compact fibrous plectenchyma 8-24 μ thick; black pseudoparenchymatous covering layer 30-60 μ thick, in region of lips but gradually thinning out towards the margins; hymenium 110-150 μ thick. Asci cylindrical, rounded at the tip, sessile, 8-spored, 130-150 x 16-17 μ. Paraphyses filiform, almost uniform in width, becoming at maturity variously hooked at tips, often swollen and slightly branched, hyaline, up to 125 μ long, 1.5 μ broad. Ascospores short, fusiform when fresh, hyaline, frequently guttulate, 27-38 x 4.5-5.5 μ, surrounded by a gelatinous envelope about 4 μ in thickness.

On Abietineae. *Pinus Banksiana* Lamb.: Ontario; Jugoslavia.—*Pinus excelsa* Wall.: New Jersey; Germany; Ireland.—*Pinus flexilis* James, Jugoslavia.—*Pinus parviflora* Sieb. & Zucc., Russia.—*Pinus peuce* Griseb., Jugoslavia.—*Pinus resinosa* Ait., Ontario.—*Pinus Strobus* L.: Connecticut, Maine, Massachusetts, New Hampshire, New York, North Carolina, Pennsylvania, Vermont, Wisconsin; New Brunswick, Nova Scotia, Ontario, Quebec; Denmark; France; Germany.—*Pinus Strobus* var. *nana* Carr., Scotland.—*Pinus sylvestris* L., Quebec.

Type Locality: Near Lille, France on various *Pinus* species.

Distribution: Central and western Europe, Wisconsin to Nova Scotia south to North Carolina.

Illustrations: Mém. Soc. Phys. Hist. Nat. Genève, **16**: pl. 2, fig. 22 a, b, c. 1861.—Tubeuf, Beiträge zur Kenntniss der Baumkrankheiten. pl. 4, fig. 4-13. 1888.—Tids. f. Skovbr. **6**:281, fig. 10, 282, fig. 11 a, b, c. 1883.—Phytopath. **3**:134, fig. 6, 7, 135, fig. 8 a, b. 1913.—N. J. Agric. Exp. Sta. Bull. **313**:25, fig. 82-86. 1917.

Exsiccati: Allescher & Schnabl, Fungi bav. 634; Krieger, Fung. sax. 1476; Krieger, Schädl. Pilze, 131; Rehm, Ascom. 1103; Sydow, Myc. germ. 1344.

Other Specimens Examined. Herbarium J. S. Boyce. On *Pinus Strobus*: 1240, Kittery Point, Me., coll. G. G. Hedgcock; 1821, West Hanover, Mass.; 1645, Mosinee, Marathon Co., Wisc., coll. J. J. Davis; 1206, 1228, near London, Ont., coll. J. Dearness; 1632, 1633, 1634, Almindingen, Bornholm, Denmark; 1062, near Hoersens, Denmark, coll. J. Lind.

Herbarium Office of Forest Pathology, U. S. Department of Agriculture. On *P. Strobus*: 16929, Saranac Inn, N. Y., coll. P. Spaulding; 2177, Bethel, Vt., coll. P. Spaulding.

Herbarium John Ehrlich. On *P. Strobus*: 94, Warrensburg, N. Y.; 715, Lake Jolly, Digby Co., N. S.

Herbarium J. H. Faull. On *P. Strobus*: 8619, 8621, Proulx, Que.—On *P. Strobus* and *P. sylvestris*, 8618, Proulx, Que.

Herbarium L. O. Overholts. On *P. Strobus*, 5477, Greenwood Furnace, Pa.

Herbarium G. D. Darker. On *Pinus Banksiana*: 2140, 2185, 2426, Lake Timagami, Ont.—On *Pinus resinosa*: 1836, 2128, 2428, 2429, Lake Timagami, Ont.—On *P. Strobus*: 3380, Hamilton, Mass.; 3559, near Old Orchard Beach, Me.; 3444, Hanover, N. H., coll. A. Povah; 1411, Lambton Mills, York Co., Ont.; 1198, 1199, 1203, 1226, 1259, 1303, 1351, 1385, 1449, 1536, 1553, 1554, 1719, 1889, 2104, 2427, 2433, Lake Timagami, Ont.

The literature relating to *Hypoderma Desmazierii* has been reviewed carefully by Graves (1913). Several European works have also dealt from time to time with this species, and those of Rostrup (1883), Tubeuf (1888, 1908), Fron (1911) and Vuillemin (1911) have covered the morphological details very completely. To date, however, these workers have ignored the work of Duby (1861) in which *H. Desmazierii* was originally described. The original description was concise but very definite and the illustrations were fairly good. Neither Rostrup nor v. Tubeuf pointed out why Duby's species was not accepted nor how their own differed from it. Although the writer has not seen Duby's material, the name *H. Desmazierii* has been employed here because it has priority over those of Rostrup and Tubeuf. Two species *Hypoderma Namyslowski* and *Lophodermium lineatum* have been more recently described by Birula et al. (1928) in Poland and by Smith and Ramsbottom (1920) in England. Both species were separated from *H. Desmazierii* chiefly because of slight variations in ascospore measurements. North American material almost always contains many spores just as large as those reported for plants described by Birula and Smith. The Polish material was also characterized by the possession of fine striations on the asci. No other characters of diagnostic value were mentioned and it is probable that both are synonymous with *H. Desmazierii*. The spore and ascus measurements reported by the writer are also larger than usually given for this species. They were obtained, however, from fresh material, and the spore measurements were made from mature spores discharged from the hysterothecia on cover glasses. It is in-

teresting to note here that spores of *H. Desmazierii* have been caught on cover glasses after having been thrown to a height of 1.2 cm. in closed vessels.

Hypoderma Desmazierii has never been observed in dense forests by the writer although it has been found in clearings along the forest edge and in plantations. It appears to be a weak parasite, but its association with clearings suggests that it may follow winter browning. The hysterothecia usually form on the brown tips of green needles, later extending the whole length of the leaf, or on the leaves of branches which have been mechanically injured. The only cultural studies attempted with this species are those reported in a later section of this paper.

Hypoderma lethale and *Hypoderma pedatum* have certain characters in common with *Hypoderma Desmazierii* but the highly organized primordium of the slit of *H. Desmazierii* sets it clearly apart from the other species.

Ascospore germination in distilled water is marked by the formation of short germ tubes, which may be simple or sometimes swollen and lobed at the apex. More rarely the germ tubes become somewhat moniliform with bead-like swellings along the hyphae. Just prior to, or at about the time of germination, the ascospores become once septate, a behavior typical of all species studied.

7. **Hypoderma robustum** v. Tubeuf in Arb. Biol. Abteil. Land- u. Forstw. Kaiserl. Gesundh. **2**(1):16 (1901).

Lophodermium infectans Mayr, Die Waldungen von Nordamerika, 336 (1890).

Hysterothecia hypophyllous, continuous or occasionally interrupted, extending along the median portion of lower surface of dead, light straw-colored needles two years of age or older, 0.27-0.50 mm. in width, opening by a longitudinal slit; lips dark, inconspicuous; disc concolorous with leaf surface; hysterothecia in cross sectional view intraepidermal in region of ostiolar slit, subepidermal and becoming subhypodermal at edges, 0.27-0.28 mm. deep; basal layer of plectenchyma colorless, of parallelly arranged hyphae, up to 30 μ thick, extending laterally up sides of hysterothecium, laterally up to 22 μ thick; black covering layer pseudoparenchymatous, rather variable

in extent and thickness but always well developed, 30-40 μ thick along margins of fissures, with a conspicuous plug of light colored, compact plectenchyma about 35 μ thick, filling the primordium of the slit of the hysterothecium; hymenium 150-200 μ thick. Asci clavate, tip at first truncated, becoming rounded at maturity, 8-spored, 138-192 x 28-35 μ. Paraphyses uniformly filiform, straight, hyaline, about 0.5 μ thick, 120-150 μ long. Ascospores mostly bacillar, occasionally fusoid or occasionally slightly constricted in middle, 27-36 x 4-8 μ surrounded by a conspicuous gelatinous sheath 5-11 μ thick while in the ascus, and up to 22 μ thick and with numerous small granules attached on outer surface of sheath after discharge of spores from ascus. Pycnidia epiphyllous, intraepidermal, maturing before the asci, in two rows one on each wing of the reddish-brown colored needle, up to 280 μ in width, concolorous, occasionally turning black after conidial discharge. Conidia hyaline, bacillar, 0.5-0.7 x 3.0-3.5 μ.

On Abietineae. *Abies amabilis* (Dougl.) Forb.: Oregon; British Columbia.—*Abies concolor* Lindl. & Gord., California, Oregon.—*Abies grandis* Lindl., California, Idaho.—*Abies magnifica* Murr., California.—*Abies magnifica* var. *shastensis* Lemm., California.—*Abies nobilis* Lindl., Oregon.

Type Locality: California, on *A. concolor*.

Distribution: Southern California to southern British Columbia.

Illustrations: Mayr, Die Waldungen von Nordamerika, pl. 10, 1 fig. a, b. 1890.—Arb. Biol. Abtheil. Land- u. Forstw. Kaiserl. Ges. **2**(1):15, fig. 3 (4c, d, e), 16, fig. 5 (1), 17, fig. 6. 1901.—Mycologia, **19**:285, fig. 1. 1927.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Abies amabilis*: 152 (part), 153, 269, Government Camp, Ore., coll. G. D. Darker; 769, Grouse Mt., Vancouver, B. C., coll. G. D. Darker.—On *Abies concolor*: 477, 478, 483, 485, 486, 491, 493, 504, 505, 506, 507, 523, 525, 547, 548, 557, 586, 588, 589, 590, 591, 592, 593, 599, 600, 601, Oregon Caves, Ore., coll. G. D. Darker.—On *Abies grandis*, 72, Priest River For. Exp. Sta., Idaho, coll. G. D. Darker.—On *Abies nobilis*, 371, 745, Government Camp, Ore.

Herbarium J. S. Boyce. On *A. amabilis*: 965, Lookout Mt., Hood River Co., Ore.; 1254, near Summit Ranger Station, Clackamas Co., Ore.; 1143, near Cloud Cap Inn, Hood River Co., Ore.—On *A. concolor*: 1755, San Bernardino Mts., Cal., coll. H. Mayr; 783, Palmdale, San Bernardino Co., Cal., coll. H. N. Putnam; 321, near Hobart Mills, Sierra Co., Cal.; 318, Bray, Cal.—On *A. grandis*, 958, Recreation, Clamath Co., Cal.

Herbarium Office of Forest Pathology, San Francisco, Cal. On *A. concolor*: SiA1, Ellis Meadow, Sierra Nat. Forest, Cal., coll. E. P. Meinecke; M(2)D28, M(2)D31, Warner Mts., Modoc Co., Cal., coll. E. P. Meinecke; PlA1, PlA6, Cromberg, Cal., coll. E. P. Meinecke; TaD101, Verde Lake, Tahoe, Cal., coll. J. S. Boyce; Sh(1)E2, near Weed, Cal., coll. J. S. Boyce.—On *Abies magnifica,* Ta(1)K400, near Cisco, Cal., coll. H. G. Lachmund.—On *A. magnifica* var. *shastensis,* Sh(1)E6, Siskiyou Co., Cal., coll. J. S. Boyce.

J. S. Boyce (1927) has reviewed the literature dealing with *Hypoderma robustum* and has established *Lophodermium infestans* Mayr as a synonym.

The parasitism of *Hypoderma robustum* has never been proven, but field observations in western America have indicated that it is the cause of the most widespread and in some localities the most destructive needle disease of Abies. In the neighborhood of Oregon Caves in the Siskiyou Mts. *H. robustum* annually causes destruction of the foliage of *Abies concolor* comparable in degree to that caused by *Bifusella Faullii* in the eastern forests. The life cycle of *H. robustum* in the western forests requires two years from the time of infection to the production of a new crop of ascospores.

Hypoderma robustum and *Bifusella Abietis* are very similar in the external appearances of both pycnidia and hysterothecia but an examination of the spores at once distinguishes the two species.

8. **Hypoderma pedatum**, sp. nov.

Hysterotheciis fuscis lineas stomatum sequentibus, raro confluentibus, amphigenis longitudinali incisura aperientibus 0.28-0.70 x 0.18-0.25 mm.; labiis obscuris; hysterotheciis in transversali sectione subepidermalibus 0.14-0.18 mm. profundis; plectenchymatico basilari strato 7-15 μ crasso; tegente strato paene achroï pseudoparenchymatis epidermidisque in medio circiter 45-60 μ crasso; hymenio 120-135 μ crasso. Ascis subclavatis octosporis 108-128 x 19-22 μ. Paraphysibus simplicibus hyalinis circiter 90-100 μ longis et circiter 1 μ crassis, in apice parum afflatis. Ascosporis bacillaribus plerisque medio leviter constrictis hyalinis 20-23 x 4-5 μ muco 3-4 μ crasso involutis.

In foliis *Pini radiatae* D. Don, Golden Gate Park, San Francisco, California; mense Augusto, 1929, Arnold Arboretum, Pathological Herbarium, 655, G. D. Darker legit.

Hysterothecia dark brown, occurring on reddish brown needles in tufted groups on dead ends of twigs, following stomatal lines, rarely confluent, amphigenous, opening by a longitudinal slit, 0.28-0.70 x 0.18-0.25 mm. in surface view; lips inconspicuous; disc colorless but appearing concolorous with leaf interior when viewed superficially; hysterothecia in cross section subepidermal, 0.14-0.18 mm. in depth (open); plectenchymatous basal layer thin, 7-15 μ; pseudoparenchymatous covering layer almost colorless, in middle about 45-60 μ thick (including epidermis); hymenium 120-135 μ thick. Asci subclavate, 8-spored, 108-128 x 19-22 μ (fresh material). Paraphyses simple, hyaline, about 90-100 μ long, about 1 μ thick, slightly swollen at tip. Ascospores bacillar, usually slightly constricted in the middle, hyaline, 26-30 x 7-8 μ in fresh material, 20-23 x 4-5 μ in dried material, surrounded by a gelatinous sheath about 3-4 μ thick.

On Abietineae: *Pinus radiata* D. Don, California.

Type Locality: Golden Gate Park, San Francisco, California on *P. radiata,* August, 1929. Arnold Arboretum, Pathological Herbarium, 655, coll. G. D. Darker.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Pinus radiata,* 655 (Type), 665, Golden Gate Park, San Francisco, Cal.

Herbarium Office of Forest Pathology, San Francisco, Cal., on *P. radiata*: SF(1)L101 (in part); Golden Gate Park, San Francisco, Cal., coll. J. S. Boyce.

The diseased needles occurred in tufted bunches on the dead ends of twigs but there was no evidence to indicate that *Hypoderma pedatum* was the primary cause of the trouble. *H. pedatum* can be easily diagnosed in the field by the small brownish hysterothecia scattered along the stomatal lines.

9. **Hypoderma lethale** Dearness in Mycologia, 18:241 (1926).

Hysterothecia amphigenous, more or less aggregated on sordid leaf areas, shining black, subepidermal but growing in deeper at margins of hysterothecia, opening narrowly by a longitudinal fissure, superficially measuring 0.42-1.40 mm. in length; hysterothecia in cross section 0.18-0.34 mm. wide, 0.13-0.21 mm. deep; plectenchymatous basal layer 18-30 μ thick; thin pseudoparenchymatous covering layer together

with connate epidermis 30-45 μ thick; hymenium 105-160 μ thick. Asci subcylindrical, rounded at tips, thin walled, 8-spored, 90-160 x 16-21 μ. Paraphyses hyaline, filiform, 1.0-1.5 μ thick, up to 150 μ long. Ascospores short, bacillar to fusiform or slightly constricted in middle, hyaline, 24-30 x 3-5 μ, surrounded by a gelatinous sheath about 4-6 μ in thickness. Pycnidia subepidermal, inconspicuous, concolorous with leaf surface.

On Abietineae: *Pinus caribaea* Morelet, Florida.—*Pinus echinata* Mill., Louisiana.—*Pinus rigida* Mill., Maine, Maryland, New Hampshire, New Jersey, New York, Virginia.—*Pinus serotina* Michx., South Carolina.—*Pinus Taeda* L., North Carolina, South Carolina, Virginia.—*Pinus virginiana* Mill., Maryland, North Carolina.

Type Locality: Highfield, Maryland on *P. rigida*.

Distribution: New England to Florida and Louisiana.

Specimens Examined. Herbarium J. S. Boyce. On *Pinus caribaea*, 1696, West St. Augustine, Fla., coll. G. G. Hedgcock.—On *Pinus rigida*: 1847, Bowdoin College, Brunswick, Me.; 1698, Takoma Park, Maryland, coll. G. G. Hedgcock; 1394, May's Landing, Atlantic Co., N. J., coll. G. G. Hedgcock; 1697, Chain Bridge, Fairfax Co., Va., coll. G. G. Hedgcock.—On *Pinus serotina*: 1365, Styx, S. C., coll. G. G. Hedgcock; 1699, near Styx, S. C., coll. G. G. Hedgcock.—On *Pinus Taeda*: 1364, Raleigh, N. C., coll. G. G. Hedgcock.—On *Pinus virginiana*: 1700, Garrett Park, Maryland, coll. G. G. Hedgcock; 1366, Black Mt., Buncome Co., N. C., coll. G. G. Hedgcock.

Herbarium J. H. Ehrlich. On *P. Taeda*: 93, Carpenter, N. C., coll. F. A. Wolf and J. Ehrlich.

Herbarium J. H. Faull. On *P. rigida*: 9235, Kittery Point, Me.

Herbarium G. D. Darker. On *P. echinata*: 3361, Urania, La., coll. L. J. Pessin.—On *P. Taeda*: 3359, Hampton Co., S. C., coll. Lewis E. Staley; 3363, near Richmond, Va., coll. J. C. Calderwood.

Hypoderma lethale has been reported by Dearness as the cause of a serious needle blight of pines in the Atlantic coast states. To date, however, its pathogenicity has never been established by experiment.

Characters of the hysterothecium readily serve to distinguish *Hypoderma lethale* from *Hypoderma Desmazierii*. The hysterothecia of the former are deep seated in the host tissue and do not possess an obvious primordium of the slit. In *H. Desmazierii* the primordium of the slit is highly organized and the hysterothecia are more superficial and do not depress the parenchyma cells of the needle.

10. **Hypoderma Hedgcockii** Dearness in Mycologia, **18**:240 (1926).

Leptostroma Hedgcockii Dearness in Mycologia, **20**:240 (1928).

Hysterothecia shining black, elliptical, amphigenous, on discolored areas on green or languishing needles, 0.38-0.68 x 0.78-1.88 mm., subhypodermal; hysterothecia in cross section up to 285 μ deep (open); covering layer (epidermis, hypoderma and dark pseudoparenchyma) 84-90 μ thick; basal plectenchyma 15-20 μ thick; hymenium up to 200 μ thick. Asci broadly cylindrical, with four normal and four minute abortive spores, 164-189 x 24-30 μ. Paraphyses filiform, slightly swollen at tips, hyaline, about 1.5-2.0 μ thick, up to 200 μ in length. Spores oblong, hyaline, normal spores 28-32 x 8-11 μ, surrounded by a conspicuous gelatinous covering up to 14 μ in thickness.

On Abietineae. *Pinus caribaea* Morelet, Florida, North Carolina.—*Pinus clausa* Vasey, Florida.—*Pinus echinata* Mill., North Carolina, Virginia.—*Pinus palustris* Mill., Florida.—*Pinus rigida* Mill., North Carolina.—*Pinus virginiana* Mill., Maryland, Tennessee.

Type Locality: Silver Springs, Florida on *P. caribaea.*

Distribution: Maryland to Florida.

Specimens Examined. Herbarium J. S. Boyce. On *Pinus caribaea*: 1691, Silver Spring, Fla., coll. G. G. Hedgcock.—On *Pinus clausa,* 1692, Bolton, Fla., coll. G. G. Hedgcock.—On *Pinus echinata,* 1693, Luray, Va., coll. G. G. Hedgcock.—On *Pinus palustris,* 1694, Croom, Fla., coll. G. G. Hedgcock.—On *Pinus virginiana,* 1695, Jamestown, Tenn., coll. G. G. Hedgcock.

Herbarium J. H. Faull. On *P. caribaea*: 7501, Pisgah Nat. Forest, N. C., coll. G. G. Hedgcock.

Herbarium G. D. Darker. On *P. palustris*: 3362, Starke, Fla., coll. P. V. Siggers.

Hypoderma Hedgcockii is a strikingly parasitic species the hysterothecia of which commonly occur on green needles, but no careful observations have ever been made concerning its etiology. The ascus of *H. Hedgcockii* with its four normal and four aborted spores is an unusual feature among the Hypodermataceae.

11. **Hypoderma saccatum,** sp. nov.

Hysterotheciis conspicuis atronitidis amphigenis 4.0-8.0 mm. longis; hysterotheciis in aspectu transversalis sectionis

subcuticularibus 0.63-0.90 mm. latis et 0.23-0.39 mm. profundis; tegente strato atri pseudoparenchymatis cuticulaeque 40-60 μ crasso; basilari strato 35-45 μ crasso; hymenio usque 180 μ crasso. Ascis late clavatis octosporis 160-185 x 27-33 μ. Paraphysibus 150-170 μ longis filiformibus 2 μ crassis in apice, quas frequenter angustae hyphae pontibus similares lateraliter conectunt. Ascosporis bacillaribus 24-36 x 4-6 μ hyalinis muco 4-5 μ crasso involutis. Pycnidiis plerisque continuis atronitidis subcuticularibus, aspectu irregulari, usque 8 mm. longis 280-525 μ latis 45-75 μ profundis; conidiophoris simplicibus hyalinis 15-25 μ longis. Conidiis bacillaribus 7-10 x 0.7-1.0 μ hyalinis.

In foliis *Pini edulis* Engelm., Cimarron, Montrose Co., Colorado, mense Iulio, 1917, Herbarium J. S. Boyce, 1490, E. Bethel legit.

Hysterothecia conspicuous, shining black, on dead tips of green needles, amphigenous, 4.0-8.0 mm. long, opening longitudinally; hysterothecia in cross section subcuticular, 0.63-0.90 mm. wide, 0.23-0.39 mm. deep (open); the dark pseudoparenchymatous covering layer 40-60 μ thick (including thickness of cuticle), extending laterally beyond cavity of hysterothecium; basal layer 35-45 μ thick, continuing laterally up sides of hysterothecium; hymenium up to 180 μ thick. Asci broadly clavate, 8-spored, 160-185 x 27-33 μ, spores confined to upper three-quarters of ascus. Paraphyses 150-170 μ long, filiform, 2 μ thick above, basally thicker and frequently connected laterally to one another by narrow bridge-like hyphae. Ascospores rod-shaped, 24-36 x 4-6 μ, hyaline, surrounded by a gelatinous sheath about 4-5 μ in thickness. Pycnidia continuous or somewhat interrupted, shining black, subcuticular, irregular in outline, up to 8 mm. long, 280-525 μ in width, 45-75 μ deep. Conidiophores simple, hyaline, 15-25 μ long. Conidia bacillar, 7-10 x 0.7-1.0 μ hyaline.

On Abietineae: *Pinus edulis* Engelm., Colorado, New Mexico.

Type Locality: Cimarron, Montrose County, Colorado on *P. edulis*, July, 1917. Herbarium J. S. Boyce 1490, coll. E. Bethel.

Distribution: Western Colorado into Northern New Mexico.

Specimens Examined. Herbarium J. S. Boyce. On *Pinus edulis*: 1490 (Type), Cimarron, Colo., coll. E. Bethel; 1498, Cedaredge, Colo., coll. G. G. Hedgcock; 1499, McCoy, Colo., coll. G. G. Hedg-

cock; 1495, Santa Fe, New Mexico, coll. G. G. Hedgcock & E. Bethel.

Hypoderma saccatum is known from a number of gatherings but no reliable information can be given concerning its prevalence or pathogenicity. In general appearance it is very similar to *Elytroderma deformans* on *Pinus edulis*. The hysterothecia of *H. saccatum,* however, are more shiny in appearance. The best diagnostic features, other than spore characters, of course, are the pycnidial characters. The pycnidia of *H. saccatum* are extremely large and shining black, while those of *E. deformans* are inconspicuous and colorless. *Hypoderma Pini,* a closely related species on *Pinus monophylla,* lacks paraphyses.

12. **Hypoderma Pini** (Dearn.), sp. nov.

Hypoderma robustum v. Tubeuf var. *Pini* Dearness in Mycologia, **16**:149 (1924).

Hysterothecia shining black, amphigenous, on needles 4-11 years of age, needles wholly or terminally brown in color, mostly 0.6-1.0 x 4.5-12.0 mm. in surface view, but may be as small as 0.4 x 0.7 mm.; hysterothecia in cross section intraepidermal, 0.4-0.5 mm. in depth, dark pseudoparenchymatous covering layer 50-65 μ thick in the middle, thinning out gradually towards the edges, sometimes thicker again at the margin; basal plectenchyma 30-45 μ thick, continuous with lateral plectenchyma, in mature hysterothecium not extending completely across the top; hymenium up to 300 μ thick; lips of the longitudinal fissure not conspicuous, black; disc concolorous with the mesophyll of the leaf. Asci clavate, tapering gradually towards the base, 8-spored, 30-39 x 180-235 μ. Paraphyses wanting. Spores mostly cylindrical, rod-shaped, but occasionally fusiform or slightly slipper-shaped, hyaline, 7.5-14 x 36-69 μ, with a gelatinous sheath 4-9 μ thick, frequently with small granules attached on the outside of the sheath. Pycnidia amphigenous, on needles 3 years of age or older, mummy brown (Ridgway) in dried specimens, often connected laterally in a labyrinthiform fashion, extremely variable in shape and size, up to 20 mm. long, intraepidermal; conidiophores simple, filiform, up to 35-40 μ in length. Conidia hyaline, bacillar, 0.5-0.8 x 7-12 μ.

On Abietineae: *Pinus monophylla* Torr. & Frem., Nevada.

Type Locality: Near Minden, Nevada on *P. monophylla.*

Distribution: Known only from western Nevada and southern California.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Pinus monophylla*: 738, Carter's Station, near Minden, Nevada, coll. G. D. Darker.

Herbarium J. S. Boyce. On *P. monophylla*: 1230, Big Bear Lake, San Bernardino County, Cal., coll. E. Bethel.

Herbarium Office of Forest Pathology, San Francisco, Cal. On *P. monophylla*: MoN2, Carter's Station, near Minden, Nevada, coll. E. P. Meinecke.

Hypoderma Pini is chiefly of mycological interest since its attack is limited for the most part to the older needles of the lower parts of trees. Material collected in 1929 showed abundant hysterothecia on needles of the years 1918 to 1925.

Hypoderma Pini most closely resembles *Hypoderma saccatum* on *Pinus edulis* but the former has aparaphysate hysterothecia which distinguish it at once from all other species. The resemblance to *Hypoderma robustum,* of which Dearness made this species a variety, is only superficial.

HYPODERMELLA von Tubeuf in Bot. Centralbl. **61**:49 (1895).

Lophodermella von Höhnel in Ber. Deut. Bot. Ges. **35**:247 (1917).

Hysterothecia innate erumpent, shining black, dark brown or colorless, short elliptical to linear, opening by a longitudinal slit, mostly extending deeply into the substratum, hymenium concave. Asci broadly clavate or subcylindric, 8-spored or with 4 spores aborted, rounded or subacute at apex. Paraphyses simple, occasionally swollen at tip, at maturity sometimes branching. Ascospores simple, elongate ovoid to clavate, swollen at tips, tapering acutely toward base, unicellular, surrounded by a conspicuous gelatinous sheath, up to three-fourths of the length of the ascus. Pycnidia simple, conidiophore layer applanate; conidia minute, bacillar. Type species: *Hypodermella Laricis* von Tubeuf.

KEY TO SPECIES OF HYPODERMELLA

a. Hysterothecia shining black, elliptical...b.
   b. Hysterothecia scattered in a row along entire length of needle, subcuticular; on Larix .....13. *H. Laricis*

b. Hysterothecia scattered irregularly, usually or frequently restricted to dead areas on living needles, subepidermal; on Pinus...c.
c. Hysterothecia limited to a narrow brown zone in middle of green needle...d.
d. Asci with four functional spores .....14. *H. limitata*
d. Asci with eight functional spores..15. *H. lacrimiformis*
c. Hysterothecia scattered over entire needle or on terminal portions of needles...e.
e. Hysterothecia scattered usually on reddish brown areas 16. *H. medusa*
e. Hysterothecia crowded on pale bleached areas...f.
f. Hysterothecia on one year old needles, about one mm. long .....17. *H. ampla*
f. Hysterothecia on two year old needles, over one mm. long .....18. *H. montana*

a. Hysterothecia brownish black or almost colorless...g.
g. Hysterothecia brownish black, "nervisequious," intraepidermal or subepidermal; on Abies...h.
h. Pycnidia light colored, concolorous with leaf surface...i.
i. Pycnidia interrupted, inconspicuous, following the sulcus on upper surface of needle .....19. *H. lirelliformis*
i. Pycnidia in two rows, one on each side of the sulcus 20. *H. mirabilis*
h. Pycnidia dark colored, following sulcus on upper surface of needle...j.
j. Pycnidia punctiform, brownish .....21. *H. punctata*
j. Pycnidia not punctiform, continuous...k.
k. Pycnidia narrow, up to 0.25 mm. in width...l.
l. Pycnidia at first dark brown, becoming almost concolorous with leaf surface after conidial discharge; hysterothecia intraepidermal 22. *H. Abietis-concoloris*
l. Pycnidia at first light brown, becoming almost black after conidial discharge; hysterothecia subepidermal .....23. *H. nervata*
k. Pycnidia broad, 0.25-0.50 mm. in width 24. *H. nervisequia*

g. Hysterothecia concolorous with needle surface or nearly so, subhypodermal; on Pinus...m.
m. Ascospores short, clavate...n.
n. Hysterothecia usually one mm. or more in length, light brown, scattered...o.
o. Hysterothecia sunken in leaf parenchyma, not strongly erumpent...p.
p. Hysterothecia with thick basal layer when immature, 2-20 mm. long .....25. *H. sulcigena*
p. Hysterothecia with thin basal layer throughout development, 1-8 mm. long ....26. *H. montivaga*

o. Hysterothecia not sunken into leaf parenchyma, strongly erumpent .....27. *H. arcuata*
n. Hysterothecia short elliptical, less than one mm. in length, concolorous with leaf surface ...28. *H. concolor*
m. Ascospores elongate, clavate, almost filiform...q.
q. Hysterothecia brownish black, frequently fused laterally into compound hysterothecia .....29. *H. conjuncta*
q. Hysterothecia concolorous with leaf surface, not fused laterally into compound hysterothecia .....30. *H. cerina*

13. **Hypodermella Laricis** v. Tubeuf in Bot. Centralbl. **61**:49 (1895).

Hypodermella Laricis var. *octospora* Dearness in Mycologia, **18**:241 (1926).
Leptothyrella Laricis Dearness in Mycologia, **20**:240 (1928).

Hysterothecia in a more or less continuous row, epiphyllous, oblong to elliptical, frequently confluent, dull black, 0.50-0.80 x 0.20-0.30 mm., opening by a longitudinal fissure; hysterothecia in cross section subcuticular, 0.12-0.18 mm. deep; basal layer of dark pseudoparenchyma 10-15 μ thick below colorless plectenchyma layer 10-15 μ thick; covering layer of dark pseudoparenchyma 23-30 μ thick; hymenium 100-110 μ thick. Asci broadly clavate, rounded above when young, becoming acutely pointed at maturity, 4 or occasionally 8-spored, 80-112 x 20-24 μ. Paraphyses considerably shorter than asci, about 1 μ thick, at maturity slightly swollen at tips. Ascospores clavate, tapering to an acute base, hyaline, 70-105 x 6.0-6.5 μ, surrounded by a gelatinous sheath about 5 μ in thickness. Pycnidia conspicuous, numerous, 120-300 x 80-120 μ. Conidia hyaline, elongated pyriform, 4.0-5.5 x 0.8-1.2 μ.

On Abietineae. *Larix decidua* Mill.: Austria; Germany.—*Larix laricina* (Du Roi) K. Koch, Ontario.—*Larix occidentalis* Nutt.: Idaho, Montana, Oregon; British Columbia.

Type Locality: Near Semmering, Austria, on *L. decidua*.

Distribution: Central Europe, Ontario, Pacific northwestern United States and adjacent Canada.

Illustrations: Arb. Biol. Abth. Kaiserl. Gesundh. **2**(1): pl. 3, fig. 1-10. 1901.

Exsiccati: Bartholomew, Fungi Col. 5029; Rehm, Ascom. 1641, 1641 b; Vestergren, Micromyc. rar. sel. 1222.

Other Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Larix occidentalis*: 6, Priest River, Idaho, coll. G. D. Darker; 91, Priest River Forest Exp. Station, Idaho, coll. G. D. Darker.

Herbarium J. S. Boyce. On *L. occidentalis*: 807, Musselshell, Idaho, coll. C. R. Stillinger; 1189, Moscow Mts., Idaho, coll. F. D. Heald & D. C. George; 1243, Moscow Mts., Idaho, coll. G. G. Hedgcock; 1509, St. Maries, Idaho, coll. G. G. Hedgcock; 1463, Saint Regis, Montana, coll. J. A. Hughes; 967, Dufur, Ore.; 1051, Mitchell, Wheeler Co., Ore.; 1249, Kelowna, B. C.; 1813, Kelowna, B. C., coll. J. R. Weir & J. S. Mielke.

Herbarium J. H. Faull. On *L. occidentalis*: 8862, Salmon Arm, B. C., coll. Alan E. Parlow; 8863, Shuswap Lake, B. C., coll. D. R. Cameron.—On *Larix laricina*, 7523, Moccasin Lake, Klock Township, Ont.

Herbarium G. D. Darker. On *L. laricina*: 1752, 1796, 1826, 1891, 1892, 1893, 1894, 2407, Lake Timagami, Ont.

Outbreaks of disease caused by *Hypodermella Laricis* have been recorded by Tubeuf (1895, 1901) in Europe and by Schmitz (1923) in America. The same species also attains economic importance in Northern Ontario where it attacks *Larix laricina*. A badly infected stand was observed by Dr. J. H. Faull in the neighborhood of Moccasin Lake, in Northern Ontario in 1924. Under suitable conditions the disease spreads rapidly through the crowns of large trees. The diseased spur shoots retain their leaves during the winter and in the following spring at the time of development of the new larch needles the ascospores are discharged. Since this organism kills not only the needles but also the spur shoots it must be recognized as a serious menace in those districts where it has become well established.

14. **Hypodermella limitata**, sp. nov.

Hysterotheciis atronitidis amphigenis in sordidis areis viridium aut languidorum foliorum, 0.3-0.5 x 0.8-2.5 mm.; hysterotheciis in transversalis sectionis aspectu subepidermalibus 210-280 x 420-560 μ; plectenchymatico basilarique strato 12-28 μ crasso; tegente strato epidermidis pseudoparenchymatisque atri 45-60 μ crasso; hymenio 150-160 μ crasso. Ascis cylindricis rotundatis in apicibus, cum quattuor normalibus sporis et quattuor abortis, 125-160 x 14-15 μ. Paraphysibus simplicibus filiformibus 1 μ crassis usque 135 μ longis. Ascosporis clavatis hyalinis 33-45 x 4.0-4.5 μ, muco 5-7 μ crasso involutis.

In foliis *Pini radiatae* D. Don, Golden Gate Park, San Francisco, California, mense Maio, 1919, Herbarium J. S. Boyce, 293, J. S. Boyce legit.

Hysterothecia shining black, amphigenous, on sordid areas on green or languishing needles, 0.3-0.5 x 0.8-2.5 mm., subepidermal, opening longitudinally; in cross section hysterothecia 210-280 x 420-560 μ; plectenchymatous basal layer 12-28 μ thick, continuing laterally up the sides of the hysterothecia; dark pseudoparenchymatous covering layer (including thickness of epidermis) 45-60 μ thick, thinning out gradually towards the margins; hymenium 150-160 μ thick. Asci cylindrical, rounded at the tips, with 4 normal and 4 aborted spores, 125-160 x 14-15 μ. Paraphyses simple, filiform, 1 μ thick, up to 135 μ in length. Ascospores clavate, hyaline, 33-45 x 4.0-4.5 μ, surrounded by a conspicuous gelatinous sheath about 5-7 μ thick.

On Abietineae: *Pinus radiata* D. Don, California.

Type Locality: Golden Gate Park, San Francisco, California on *P. radiata,* May, 1919, Herbarium J. S. Boyce, 293, coll. J. S. Boyce.

Distribution: Known only from the type locality and the Monterey Peninsula, Cal.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Pinus radiata*: 656, Golden Gate Park, San Francisco, Cal., coll. G. D. Darker.

Herbarium J. S. Boyce. On *Pinus radiata*: 291, 1629, Monterey, Cal., coll. E. P. Meinecke; 292, 293, 294, 295, 296, Golden Gate Park, San Francisco, Cal.

Hypodermella limitata infects only short portions of the needles. It is usually restricted to sections a few millimeters long located in the centre of green or languishing needles. The only other species with this peculiar habit of growth is *Hypodermella lacrimiformis* on *Pinus attenuata.* In the asci of *H. limitata* only four spores mature while in *H. lacrimiformis* the full complement is present and normal.

15. **Hypodermella lacrimiformis,** sp. nov.

Hysterotheciis atronitidis amphigenis in sordidis areis viventium foliorum conspersis, 0.21-0.63 x 0.56-3.50 mm. saepe confluentibus; hysterotheciis in transversalis sectionis aspectu supepidermalibus 0.26-0.35 mm. profundis; basilari plectenchymate achroö 15-23 μ crasso; tegmine atri pseudoparenchymatis epidermisque 70-85 μ crasso; hymenio 165-195 μ crasso. Ascis clavatis octosporis 150-195 x 18-23 μ. Paraphysibus filiformibus in apicibus parum afflatis 0.5 μ crassis

usque 165 μ longis. Ascosporis late clavatis brevibus hyalinis 24-38 x 4.5-6.0 μ, muco 5-11 μ crasso involutis.

In foliis *Pini attenuatae* Lemmon, Oregon Caves, Josephine County, Oregon, mense Augusto, 1929, Arnold Arboretum, Pathological Herbarium, 508, G. D. Darker legit.

Hysterothecia shining black, amphigenous, scattered on sordid areas on living needles, 0.21-0.63 x 0.56-3.50 mm., often confluent, opening by a longitudinal slit, subepidermal; hysterothecia in cross section 0.26-0.35 mm. deep; basal layer of plectenchyma colorless, 15-23 μ thick, continuous up sides of hysterothecium; dark covering layer of pseudoparenchyma and epidermis 70-85 μ thick, thinning out abruptly at margins; hymenium 165-195 μ thick. Asci clavate, 8-spored, rarely 4 spores aborted, 150-195 x 18-23 μ. Paraphyses filiform, slightly swollen at tips, 0.5 μ thick, up to 165 μ long. Ascospores broadly clavate, short, hyaline, 24-38 x 4.5-6.0 μ (dry herbarium material) up to 8 μ broad (fresh material), surrounded by a broad conspicuous gelatinous sheath 5-11 μ thick.

On Abietineae: *Pinus attenuata* Lemmon, California, Oregon.

Type Locality: Oregon Caves, Oregon on *P. attenuata,* August, 1929, Arnold Arboretum, Pathological Herbarium, 508, coll. G. D. Darker.

Distribution: Known only from southern Oregon and San Francisco, California.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Pinus attenuata*: 508, Oregon Caves, Josephine County, Ore., coll. G. D. Darker; 660, Golden Gate Park, San Francisco, California, coll. G. D. Darker.

Short sections of the needles are killed by *Hypodermella lacrimiformis* just as in the case of the preceding species. Both species possess sharply marked characters and can be readily distinguished from any other species.

16. **Hypodermella medusa** Dearness in Mycologia, **16**:152 (1924).

Hysterothecia scattered on browned needles, amphigenous, black, superficially 0.40-0.53 x 0.70-21.00 mm.; hysterothecia in cross section subepidermal, at edges becoming subhypodermal, 340-750 μ wide, 240-300 μ deep (open); black pseudoparenchymatous covering layer 60-75 μ thick (inclusive of

thickness of epidermis); plectenchymous basal layer hyaline, 15-35 μ thick, extending laterally up the sides of the hymenium; hymenium 150-170 μ thick. Asci clavate, truncate-rostriform at tip, 8-spored, 18-27 x 130-180 μ. Paraphyses filiform, 105-135 μ long, 1.0-1.5 μ thick, somewhat swollen at tip. Ascospores clavate, usually conspicuously attenuated in lower half, hyaline, 3-6 x 66-75 μ, with gelatinous sheath 3-6 μ thick.

On Abietineae. *Pinus contorta* Douglas, Colorado.—*Pinus Jeffreyi* Murr., California.—*Pinus ponderosa* Douglas, California, Colorado.—*Pinus ponderosa* var. *scopulorum* Engelm., Colorado.

Type Locality: Cisco, Placer County, California on *P. Jeffreyi.*

Distribution: Northern California and Colorado.

Specimens Examined. Herbarium J. S. Boyce. On *Pinus contorta*: 1484, Allenspark, Colo., coll. G. G. Hedgcock; 1486, Allenspark, Colo., coll. Johnston & Thomson.—On *Pinus Jeffreyi,* 308, Cisco, Cal., coll. A. S. Rhoads, H. G. Lachmund & J. S. Boyce.—On *Pinus ponderosa,* 6, Bray, Cal.—On *P. ponderosa* var. *scopulorum*: 1488, Allenspark, Colo., coll. G. G. Hedgcock & Johnston; 1489, Palmer Lake, El Paso County, Colo., coll. E. Bethel & G. G. Hedgcock.

Herbarium Office of Forest Pathology, San Francisco, Cal. On *P. Jeffreyi,* Angeles G 202, Converse Exp. Station, Angeles Nat. Forest, coll. J. Sheldon.—On *P. ponderosa*: LaE44, Eagle Lake, Lassen County, Cal., coll. E. P. Meinecke; ShD3, near Antelope Ranger Station, Siskiyou County, Cal.

Herbarium G. D. Darker. On *P. ponderosa,* 3475, Cascade, Colo., coll. Carl Hartley.

Hypodermella medusa is an important species in some localities but very little is known of its pathogenicity. It belongs to a group of species in which parasitism is highly developed and the few observations that have been made indicate that it behaves in the same manner as the others. *H. medusa* is most closely related to *Hypodermella ampla* and *Hypodermella montana* but its spores are distinctly attenuated toward the base.

17. **Hypodermella ampla** (Davis) Dearness in Mycologia, **16**:152 (1924).

Lophodermium amplum Davis in Trans. Wisc. Acad. Sci. Arts & Lett. **19**:695 (1919).

Hysterothecia scattered on pale sordid areas on living or dead needles, frequently confluent, amphigenous, black, 0.70-1.35 x 0.35-0.66 mm., disc in fresh material orient pink (R) due to

color of interior of needle; hysterothecia in cross section subepidermal, 0.25-0.42 mm. deep, in early stages subcircular in outline; light colored basal plectenchyma extending uniformly up sides of hysterothecium, 15-25 μ thick; covering layer of dark pseudoparenchyma and epidermis 70-90 μ thick, pseudoparenchyma invading epidermis and extending laterally slightly beyond the limits of the hysterothecium, tapering gradually towards margins, with a lighter colored, thinner walled middle portion through which the rupture of the hysterothecium takes place; hymenial layer 150-225 μ thick. Asci clavate, 8-spored, 120-225 x 20-35 μ. Paraphyses simple, filamentous, about as long as the asci. Ascospores tapering toward the base, clavate, hyaline, 60-130 x 8 μ (fresh condition), 3-5 μ broad (dried material), with a gelatinous sheath 3-7 μ thick. Pycnidia simple, applanate, concolorous with leaf surface. Conidia bacillar, hyaline, 4.5-7.0 x 0.8-1.0 μ.

On Abietineae. *Pinus Banksiana* Lamb.: Michigan, Wisconsin; Nova Scotia, Ontario.

Type Locality: Muscoda, Wisconsin on *P. Banksiana*.

Distribution: Nova Scotia to Wisconsin.

Exsiccati: Davis, Fungi Wisc. 70.

Other Specimens Examined. Herbarium J. S. Boyce. On *Pinus Banksiana*: 1396, Roscommon, Mich., coll. R. G. Pierce; 1462, Muscoda, Wisc., coll. J. J. Davis; 1623, Arena, Wisc., coll. J. J. Davis.

Herbarium J. H. Faull. On *P. Banksiana*, 7505, Necedah, Wisc., coll. J. J. Davis.

Herbarium G. D. Darker. On *P. Banksiana*: 3371, Waverley Sanctuary, Halifax County, N. S., coll. J. H. Faull & J. Ehrlich; 3519, Biscotasing, Ont., coll. K. Schedl; 1471, 1481, 1526, 1534, 1547, 1563, 1816, 1936, 1957, 1966, 2305, Lake Timagami, Ont.

Hypodermella ampla is the cause of a destructive needle casting. The attack is often so severe that all one year old needles are shed leaving only the young needles of the current season.

Observations made on fresh material in Northern Ontario about the first of July showed the black hysterothecia scattered over light buff (Ridgway, 1912) areas which were frequently delimited by sudan brown (R) zones from the green portions of the needles. In other cases the hysterothecia were seated on auburn colored needle extremities. In freshly collected hysterothecia the disc was orient pink (R) due to the color of the interior of the host needle.

18. **Hypodermella montana**, sp. nov.

Hysterotheciis conspersis amphigenis atronitidis ellipticis 0.45-0.78 x 1.0-7.5 mm.; hysterotheciis in transversalis sectionis aspectu subepidermalibus 315-455 μ profundis; basilari plectenchymate achroö 15-45 μ crasso; tegente strato atri pseudoparenchymatis epidermidisque 48-75 μ crasso; hymenio 165-240 μ crasso. Ascis octosporis late clavatis 180-240 x 30-33 μ abrupte ad apicem versus attenuatis. Paraphysibus filiformibus 150-200 μ longis 1.0-1.5 μ crassis, parum afflatis in apice. Ascosporis clavatis 70-105 x 5-6 μ, muco 6-10 μ crasso involutis.

In sordidis areis mortuarum aut in parte viventium foliorum *Pini contortae* Douglas, Phillips, Vade P. O., Eldorado County, California, mense Septembri, 1929, Arnold Arboretum, Pathological Herbarium, 711, G. D. Darker legit.

Hysterothecia scattered on sordid areas, frequently on living green needles, with sordid areas separated from green tissues by a narrow orange brown zone, amphigenous, elliptical, 0.45-0.78 x 1.0-7.5 mm., shining black; hysterothecia in cross sectional view subepidermal, elliptical to subcircular in outline when closed, 315-455 μ deep; basal plectenchyma 15-45 μ thick, colorless, continuous laterally up the sides of the hysterothecium; dark pseudoparenchymatous covering layer and epidermis 48-75 μ thick, pseudoparenchyma extending laterally somewhat beyond the cavity of the hysterothecium; hymenium 165-240 μ thick. Asci 8-spored, broadly clavate, 180-240 x 30-33 μ, tapering abruptly to truncate tip, tip rounded at maturity. Paraphyses filiform, 150-200 μ long, 1.0-1.5 μ thick, slightly swollen at tip. Ascospores clavate, 70-105 x 5-6 μ, surrounded by a conspicuous gelatinous sheath 6-10 μ thick.

On Abietineae: *Pinus contorta* Douglas, California, Idaho, Oregon.

Type Locality: Phillips, Vade P. O., Eldorado County, California, on *P. contorta,* September, 1929, Arnold Arboretum, Pathological Herbarium, 711, coll. G. D. Darker.

Distribution: Idaho to California.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Pinus contorta*: 689, 711, 712, Phillips, Vade P. O., Eldorado County, Cal., coll. G. D. Darker; 732, Glen Alpine Springs, Fallen Leaf Lake, Eldorado County, Cal., coll. G. D. Darker; 733, near Camp Richardson, Lake Tahoe, Cal., coll. G. D. Darker; 734,

near Meyers Ranger Station, Eldorado County, Cal., coll. G. D. Darker; 64, Coolin, Priest Lake, Idaho, coll. G. D. Darker; 346, 362, 265 (in part), Government Camp, Ore., coll. G. D. Darker.

Herbarium J. S. Boyce. On *P. contorta*, 298, Hobart Mills, Sierra County, Cal.

Herbarium Office of Forest Pathology, San Francisco, Cal. On *P. contorta*: SeA4, Huckleberry Meadows, Sequoia National Forest, Cal., coll. E. P. Meinecke; Pl(1)F17, Grizzly Valley, Plumas County, Cal., coll. F. Gravatt.

This species is extremely prevalent in the Sierra Nevada Mountains in the region of the southwestern end of Lake Tahoe, California. Its nearest ally is *Hypodermella ampla* (Davis) Dearness from which it differs only in minor details. Measurements of this species average larger than those of *H. ampla*. Hysterothecia occur on 2 year old needles whereas in *H. ampla* they are present on 1 year old needles. The hysterothecia mature chiefly from July to September while in *H. ampla* they are mature as early as May in northern Ontario.

19. **Hypodermella lirelliformis,** sp. nov.

Hysterotheciis hypophyllis nervisequis continuis aut interruptis 0.25-0.42 mm. latis atrofuscis; labiis atris obscuris; disco lurido; hysterotheciis in transversalis sectionis aspectu intraepidermalibus 0.21-0.25 mm. profundis; basilari plectenchymate 20-30 μ crassa; tegente strato atri pseudoparenchymatis parietisque epidermalis 35-45 μ crasso; hymenio 120-135 μ crasso. Ascis clavatis cylindricisque octosporis truncatis rostriformibusque in apice 95-135 x 20-24 μ. Paraphysibus simplicibus filiformibus 100-120 μ longis circiter 1 μ crassis. Ascosporis filiformibus clavatis 68-75 x 2.0-2.5 μ muco 2.5-3.0 μ crasso involutis. Pycnidiis interdum deficientibus sed vulgo interruptum aut subinde continuum ordinem formantibus 125-165 μ latis, folii superficiei concoloribus.

In foliis *Abietis albae* Mill., Frankensteiner Kopf, Austria (Nassau), vere, Herbarium Barbey-Boissier 976 (in Herbario Farlow), L. Fuckel legit.

Hysterothecia hypophyllous, nervisequious on straw-colored needles, continuous or interrupted, 0.25-0.42 mm. in width, brownish black, opening by a longitudinal slit; lips dark, inconspicuous; disc pale yellow; hysterothecia in cross section intraepidermal, 0.21-0.25 mm. deep; plectenchymatous basal

layer 20-30 μ thick; covering layer of epidermal wall and dark pseudoparenchyma 35-45 μ thick; hymenium 120-135 μ thick. Asci clavate cylindric, 8-spored, truncate rostriform at tip, 95-135 x 20-24 μ. Paraphyses simple, filiform, 100-120 μ long, about 1 μ thick. Ascospores filiform clavate, 68-75 x 2.0-2.5 μ, surrounded by a gelatinous sheath 2.5-3.0 μ thick. Pycnidia sometimes lacking but usually forming an interrupted or occasionally continuous row, 125-165 μ in width, concolorous with the needle surface.

On Abietineae: *Abies alba* Mill., Austria, Germany.

Type Locality: Frankensteiner Kopf, Austria (Nassau), on *A. alba,* spring, Herbier Barbey-Boissier 976 (in Farlow Herbarium), coll. L. Fuckel.

Distribution: Central Europe.

Exsiccati: Fuckel, Fungi rhen. 2559; Linhart, Fungi hungar. 65 (in part); Rabenhorst, Fungi europ. 2144; Thümen, Myc. univ. 463 (in part).

Other Specimens Examined. Herbarium W. G. Farlow. On *Abies alba*: 976 Herbier Barbey-Boissier, Frankensteiner Kopf, Austria, coll. L. Fuckel.

Illustrations and descriptions of *Hypodermella nervisequia* differ greatly in details. It is obvious that certain of the European descriptions have been based upon *Hypodermella lirelliformis* and not on *H. nervisequia.* The two species can be readily separated from one another on pycnidial characters. The pycnidia of *H. lirelliformis* are inconspicuous and colorless while those of *H. nervisequia* are broad and dark in color forming conspicuous fructifications along the furrow on the upper surface of the needles.

20. **Hypodermella mirabilis,** sp. nov.

Hysterotheciis hypophyllis nervisequis rubide fuscis 0.34-0.41 mm. latis; labiis obscuris; hysterotheciis in aspectu transversalis sectionis intraepidermalibus in medio, marginem versus subepidermalibus, 0.22-0.27 mm. profundis; basilari strato laxi plectenchymatis 25-40 μ crasso; tegente strato epidermalis parietis pseudoparenchymatisque candidae 25-40 μ crasso; hymenio 120-150 μ crasso. Ascis late fusiformibus octosporis 120-160 x 25-33 μ. Paraphysibus tenuibus filiformibus circiter eadem longitudine atque ascis. Ascosporis cylindricis usque clavatis ad acutam basin abrupte attenuatis,

65-85 x 6-7 μ, muco 5-6 μ latitudine involutis. Pycnidiis epiphyllis achrois, raro rubidis, vulgo elongatam pustulam secus utrumque folii latus formantibus, interdum secus nervum duabus pustulis coalescentibus. Conidiis bacillaribus 2.4-3.0 x 0.7-0.9 μ.

In foliis *Abietis balsameae* (L.) Mill., Bear Island, Lake Timagami, Ontario, mense Augusto, 1925, Arnold Arboretum, Pathological Herbarium, 817, G. D. Darker legit.

Hysterothecia hypophyllous, nervisequious, dark reddish brown in color, 0.34-0.41 mm. in width; lips inconspicuous; hysterothecia in cross section intraepidermal in the middle, becoming subepidermal towards edges, 0.22-0.27 mm. deep; basal layer of loose plectenchyma 25-40 μ thick; covering layer of epidermal wall and light colored pseudoparenchyma 25-40 μ thick; hymenium 120-150 μ thick. Asci broadly fusiform, 8-spored, 120-160 x 25-33 μ. Paraphyses slender, filiform, about same length as asci. Ascospores cylindrical to clavate, tapering abruptly to an acute base, 65-85 x 6-7 μ, with a gelatinous sheath 5-6 μ in thickness. Pycnidia epiphyllous, colorless, rarely dark reddish brown, usually forming an elongated pustule along each wing of the needle, occasionally with the two pustules coalescing along the nerve. Conidia bacillar, 2.4-3.0 x 0.7-0.9 μ.

On Abietineae. *Abies balsamea* (L.) Mill.: Michigan; Ontario, Quebec.

Type Locality: Lake Timagami, Ontario on *A. balsamea,* August 1925, Arnold Arboretum, Pathological Herbarium, 817, coll. G. D. Darker.

Distribution: Gaspé Peninsula, Quebec to Isle Royale, Michigan.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Abies balsamea*: 817 (Type), Lake Timagami, Ontario, coll. G. D. Darker.

Herbarium J. H. Faull. On *A. balsamea*: 9322 (in part), Lake Timagami, Ont.; 8739, 9072, Claude Lake, Gaspé County, Quebec.

University of Michigan Herbarium. On *A. balsamea,* Isle Royale, Mich., coll. A. Povah.

Herbarium G. D. Darker. On *A. balsamea*: 1546, 1549, 1561, 1604, 1722, 1828, 2135, 2366, Lake Timagami, Ont.

In eastern America *Hypodermella mirabilis* is associated with two other "nervisequious" species on *Abies balsamea.* The characters of *H. mirabilis* are more or less intermediate

between those of *Bifusella Faullii* and *Hypodermella nervata*. In spore form it approaches the latter more closely but in spore germination it resembles the former, producing striking appressorium-like pads at the ends of the germ tubes. In the field *H. mirabilis* can always be identified by its pycnidia which form two lines, one along each wing of the needle.

21. **Hypodermella punctata**, sp. nov.

Hysterotheciis continuis aut interdum interruptis nerviseque hypophyllis 0.19-0.29 mm. latis atrofuscis; labiis nigris obscuris; hysterotheciis in transversalis sectionis aspectu intraepidermalibus 150-200 μ profundis; tegente strato exterioris epidermalisque parietis pseudoparenchymatisque atri 33-45 μ crasso; basilari plectenchymate 18-24 μ crasso; hymenio 140-150 μ crasso. Ascis clavatis typice quadrisporis cum rudimentis quattuor accessoriarum sporarum, 105-150 x 22-24 μ. Paraphysibus filiformibus simplicibus in apice circiter 0.5 μ crassis, crassioribus in basi, usque 150 μ longis. Ascosporis filiformibus clavatisque hyalinis 78-100 x 3.0-4.5 μ muco 4-6 μ crasso involutis. Pycnidiis epiphyllis intraepidermalibus, in uno vel duobus ordinibus conspersis, 0.18-1.00 mm. longis et 0.08-0.21 mm. latis, in transversali sectione applanatis, 35-42 μ crassis; conidiophoris simplicibus 10-15 μ longis, in exili basilarique strato 5-7 μ crasso sitis. Conidiis bacillaribus hyalinis 4-6 x 0.6-1.0 μ.

In foliis *Abietis nobilis* Lindl., Oregon Caves, Josephine County, Oregon, mense Augusto, 1929, Arnold Arboretum, Pathological Herbarium, 513, G. D. Darker legit.

Hysterothecia continuous along middle of lower surface of tawny or reddish brown colored, three year old needles, occasionally interrupted, 0.19-0.29 mm. in width, brownish black in color, opening by a longitudinal fissure; lips black, inconspicuous; hysterothecia in cross sectional view intraepidermal, 150-200 μ deep; covering layer of outer epidermal wall and dark pseudoparenchyma 33-45 μ thick; basal plectenchyma 18-24 μ thick, extending laterally up the sides of the hysterothecium in a narrow band; hymenium 140-150 μ thick. Asci clavate, tip somewhat truncate rostriform when young, 4-spored with rudiments of four additional spores also present, 105-150 x 22-24 μ. Paraphyses filiform, simple, terminally

about 0.5 μ thick, thicker towards base, up to 150 μ long. Ascospores filiform clavate, hyaline, 78-100 x 3.0-4.5 μ, surrounded by a conspicuous gelatinous sheath about 4-6 μ in thickness. Pycnidia epiphyllous, intraepidermal, in one or two scattered rows, appearing as small rounded or elliptical waxy blisters, dark brown at time of conidial discharge, 0.18-1.00 mm. long, 0.08-0.21 mm. wide; in cross section applanate, 35-42 μ thick; conidiophores simple, 10-15 μ long, seated on a thin basal layer 5-7 μ thick. Conidia bacillar, hyaline, 4-6 x 0.6-1.0 μ.

On Abietineae. *Abies amabilis* (Dougl.) Forb., Oregon.—*Abies balsamea* (L.) Mill., Quebec.—*Abies concolor* Lindl. & Gord., Oregon.—*Abies grandis* Lindl., Idaho.—*Abies Mariesii* Mast., Japan.—*Abies nobilis* Lindl., Oregon.

Type Locality: Oregon Caves, Josephine County, Oregon, on *A. nobilis*, August, 1929. Arnold Arboretum, Pathological Herbarium, 513, coll. G. D. Darker.

Distribution: Idaho, Oregon, Quebec and Japan.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Abies amabilis*: 160, Mt. Hood Loop Road, Hood River County, Ore., coll. L. N. Goodding & G. D. Darker; 245, Mud Creek, Clackamas County, Ore., coll. G. D. Darker; 250, 251, Mud Creek Trail, Clackamas County, Ore., coll. G. D. Darker; 341, near Shellrock Lake, Clackamas County, Ore., coll. G. D. Darker.—On *Abies concolor*: 545, 602, Oregon Caves, Josephine County, Ore., coll. G. D. Darker.—On *Abies grandis*, 135, Santa, Idaho, coll. G. D. Darker.—On *Abies nobilis*: 513, 514, Oregon Caves, Josephine County, Ore., coll. G. D. Darker.

Herbarium J. H. Faull. On *Abies balsamea*: 8631, 8635, 8637, 8646, Claude River, Gaspé County, Que.; 8678, 8772, 9071 (in part), 9082, Claude Lake, Gaspé County, Que.

Although widely distributed this species is not well known. It is rarely collected in a fruiting condition. The pycnidial characters are very striking and will alone suffice in making a determination of the species.

The Japanese record for *Hypodermella punctata* is from a doubtful citation by Tubeuf (1901) based upon an immature specimen with pycnidia of the type described for *H. punctata*.

22. **Hypodermella Abietis-concoloris** (Mayr) Dearness in Mycologia, **16**:150 (1924).

Lophodermium abietis-concoloris Mayr, Die Waldungen von Nordamerika, 336 (1890).

Hysterothecia hypophyllous, nervisequious on brown, 2—

several year old attached needles, 0.50-1.05 mm. wide, black, sometimes with a bluish black lustre; hysterothecia in cross sectional view intraepidermal in centre and frequently becoming subepidermal at edges, 360-450 μ deep (open), basal layer plectenchymatous, colorless, 15-25 μ thick, extending in a thinner layer up sides of hysterothecium; covering layer 60-120 μ thick (including epidermis wall), pseudoparenchyma dark brown, thinning out laterally; hymenium 140-180 μ thick. Asci 8-spored, clavate, 150-180 x 16-20 μ, rounded at tip but slightly rostriform when young, tapering gradually towards the base. Paraphyses simple, filiform, about 1 μ in thickness and up to 135 μ long, very inconspicuous at maturity. Ascospores clavate, 70-104 x 4-5 μ (fresh material), surrounded by a gelatinous sheath 2-4 μ thick. Pycnidia continuous or frequently interrupted, in groove of upper surface of needle, occasionally forming a double interrupted row, dark brown, becoming lighter in color after conidial discharge, 55-215 μ in width; in cross section intraepidermal, 90-105 μ in depth; conidiophores simple, 18-30 μ long, arising from a compact basal layer of plectenchyma 10-15 μ thick. Conidia bacillar, hyaline, 4-6 x 0.7-1.0 μ.

On Abietineae. *Abies amabilis* (Dougl.) Forb., California, Oregon.—*Abies concolor* Lindl. & Gord., California, Colorado, Oregon.—*Abies grandis* Lindl., Idaho, Oregon.—*Abies nobilis* Lindl., Oregon.

Type Locality: Near Mt. Shasta, California on *A. concolor*.

Distribution: Central Rocky Mts. to Pacific Northwest.

Illustrations: Mayr, Die Waldungen von Nordamerika, pl. 10, 1 fig. a, b. 1890.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Abies concolor*: 499, 500, 501,. 502, 544, 612, Oregon Caves, Josephine County, Ore., coll. G. D. Darker; 569, Grayback Creek, Josephine County, Ore., coll. G. D. Darker; 570, Sucker Creek, Josephine County, Ore., coll. G. D. Darker.—On *Abies grandis*: 133, 134, Santa, Idaho, coll. G. D. Darker.—On *Abies nobilis*: 337, 354, near Shellrock Lake, Clackamas County, Ore., coll. G. D. Darker.

Herbarium J. S. Boyce. On *Abies amabilis*: 320, Lights Creek, Plumas County, Cal.; 1252, 1741, Government Camp, Ore.—On *A. concolor*: 1501, La Veta, Cal., coll. G. G. Hedgcock; 1229, Colorado, coll. G. G. Hedgcock, E. Bethel & Johnston; 732, Whitney, Ore.; 1074, Odessa, Ore.—On *A. grandis*: 718, Bates, Ore.—On *A. nobilis*: 1251, Government Camp, Ore.

Herbarium Office of Forest Pathology, San Francisco, Cal. On

A. concolor: Pl(2)F7, Engle's Caves Camp, Plumas County, Cal., coll. J. S. Boyce; Pl(2)K400, Cascade, Plumas County, Cal., coll. H. G. Lachmund.

Hypodermella Abietis-concoloris is a serious parasite of *Abies concolor* and other species of Abies. The name was first applied by Mayr to a species found in the neighborhood of Mt. Shasta on *A. concolor*. As used by Mayr (1890) the name was a nomen nudum but Dearness revived it for the common Hypodermella type on *A. concolor*. The writer has not seen Mayr's material but judging by his illustrations and certain other evidence the organism described here seems to be the same species.

Hypodermella Abietis-concoloris is very similar to *Hypodermella nervata* on *Abies balsamea* but is distinguished from it by a number of minor characters. The former is more robust and develops in the epidermal layer, while *H. nervata* is subepidermal.

23. **Hypodermella nervata**, sp. nov.

Hysterotheciis hypophyllis raro epiphyllis continuis aut interdum interruptis atrofuscis longitrorsum aperientibus; labiis atris; disco lurido; hysterotheciis in transversalis sectionis aspectu subepidermalibus 0.45-0.60 mm. latis et 0.21-0.29 mm. profundis; basilari plectenchymate 10-21 μ crasso; tegente epidermidis pseudoparenchymatisque atri strato 60-98 μ crasso; hymenio 125-200 μ crasso. Ascis cylindricis usque clavatis octosporis 130-208 x 17-27 μ. Paraphysibus filiformibus hyalinis 1.5 μ crassis circiter 120 μ longis. Ascosporis filiformibus clavatisque hyalinis 70-90 x 2.5-3.5 μ, muco 3-6 μ crasso involutis. Pycnidiis epiphyllis subepidermalibus interdum intraepidermalibus ad margines, typice in uno ordine, continuis aut interruptis, folii superficiei concoloribus, fuscescentibus post conidiorum emissionem; pycnidiis in transversali sectione 50-330 μ latis et 50-75 μ profundis; conidiophoris simplicibus cylindricis 15-27 μ longis et 1.5-3.0 μ crassis, ex plectenchymatis strato orientibus. Conidiis hyalinis ovatis 4.5-6.0 x 1.0-1.2 μ.

In foliis *Abietis balsameae* (L.) Mill., Lake Timagami, Ontario, mense Iunio, 1922, Herbarium J. H. Faull, 6520, J. H. Faull legit.

Hysterothecia continuous along the middle of the lower surfaces of dead or partially green needles, occasionally interrupted, rarely occurring on the upper surfaces, dark brownish black, opening by a sharply defined longitudinal fissure; lips dark; disc colorless but appearing pale yellow due to underlying leaf tissue; hysterothecia in cross sectional view subepidermal, 0.45-0.60 mm. wide, 0.21-0.29 mm. deep; basal plectenchyma 10-21 μ thick; covering layer of epidermis and dark pseudoparenchyma 60-98 μ thick; hymenium 125-200 μ thick. Asci cylindrical to clavate, 8-spored, 130-208 x 17-27 μ. Paraphyses filiform, almost straight, hyaline, 1.5 μ thick, about 120 μ long, at maturity sometimes branching and cutting off sporelike cells. Ascospores filiform clavate, hyaline, 70-90 x 2.5-3.5 μ, surrounded by a conspicuous gelatinous sheath 3-6 μ thick. Pycnidia epiphyllous, subepidermal, occasionally intraepidermal at margins, in a single row or rarely double, continuous or interrupted, concolorous with leaf surface, usually becoming almost black after conidial discharge; pycnidia in cross section 50-330 μ wide and 50-75 μ deep; conidiophores simple, cylindrical, 15-27 μ long, 1.5-3.0 μ thick, arising from a plectenchymatous layer. Conidia hyaline, ovate, 4.5-6.0 x 1.0-1.2 μ.

On Abietineae. *Abies balsamea* (L.) Mill.: Maine, New Hampshire, Vermont; Nova Scotia, Ontario, Quebec.

Type Locality: Lake Timagami, Ontario on *A. balsamea,* June, 1922, Herbarium J. H. Faull, 6520, coll. J. H. Faull.

Distribution: Northern Ontario to northern New England.

Specimens Examined. Herbarium J. S. Boyce. On *Abies balsamea*: 1835 (in part), near Smyrna Mills, Aroostook County, Me.

Herbarium K. S. Chester. On *A. balsamea*: 598, Lost River, N. H.

Herbarium J. H. Faull. On *A. balsamea*: 5366, 6520 (type), 6522 (in part), 6523, 7167, 9322 (in part), Lake Timagami, Ont.; 8684 (in part), 8685, Claude Lake, Gaspé County, Que.; 8816, Claude, Que.

Herbarium G. D. Darker. On *A. balsamea*: 3557, near Old Orchard Beach, Me.; 3591, Mt. Washington, N. H., coll. J. H. Faull; 3475, Alma, N. S., coll. A. W. Slipp & J. Ehrlich; 1926, Bradford, Ont., coll. Miss L. M. Hunter; 1922, Blue Springs, Wellington County, Ont.; 1077, 1110, 1171, 1244, 1269, 1296, 1304, 1427, 1502, 1503, 1511, 1626, 1649, 1650, 1651, 1652, 1710, 1846, 1847, 1848, 1918, 2047, 2130, 2203, Lake Timagami, Ont.

Hypodermella nervata ranks next to *Bifusella Faullii* in im-

portance among the Hypodermataceae on *Abies balsamea*. Trees attacked by *H. nervata* are usually more mature than those infected with *B. Faullii*.

Hypodermella nervata is most closely related to *Hypodermella nervisequia* of Europe and *Hypodermella Abietis-concoloris* of the Pacific coast region. It can be distinguished from the former by its narrower pycnidia and from the latter by its subepidermal hysterothecia. The hysterothecia of *H. Abietis-concoloris* are intraepidermal.

Definite color changes take place in the diseased needles during the life cycle of the organism. A few observations were recorded from a collection obtained during the early part of May in Northern Ontario. At that time the needles bearing pycnidia varied from sayal brown (Ridgway, 1912) to Mikado brown (R). Leaves with slightly overmature ascigerous fructifications were light buff (R) color. The discs of the hysterothecia were between ochraceous buff (R) and light ochraceous buff (R), the color of course being due to that showing through from the leaf tissue beneath.

Ascospores of *Hypodermella nervata* germinate readily in distilled water forming stout germ tubes with characteristically constricted swellings. The tubes develop apparently from any part of the spore, which at the time of germination becomes two-celled.

24. **Hypodermella nervisequia** (De Candolle ex Fries) Lagerberg in Medd. Stat. Skogsförsöksanst. **7**:148 (1910).

Hypoderma nervisequium De Candolle, Fl. Franç. **6**:167 (1815).—Fuckel, Symb. Myc. 258 (1869).

Lophoderma nervisequum Chevallier in Jour. de Phys. **94**:31 (1822).

Hysterium nervisequium Fries, Syst. Myc. **2**:587 (1823).

Hypodermium nervisequum Link, Sp. Pl. **6**(2):89 (1824).

Lophodermium nervisequum Chevallier, Fl. Paris, **1**:435 (1826).

Schizoderma nervisequum Duby, De Candolle & Duby, Bot. Gall. **2**:885 (1830).

Lophodermium nervisequium Rehm, Kryptog.-Fl. Deutschl. **1**(3):44 (1877).

Daedalea nervicola Hazslinsky in Verh. Zool.-bot. Ges. Wien, **37**:154 (1887).

Hypodermina nervisequia v. Höhnel in Sitzungsber. Akad. Wien Math.-Naturw. Klasse, I. **125**:54 (1916).

Hysterothecia continuous or occasionally interrupted, hypophyllous, extending along the middle of the needle, 0.28-0.49 mm. wide, brownish black, opening by a longitudinal slit; lips dark, inconspicuous; disc pale yellow; hysterothecia in cross section intraepidermal, 0.24-0.26 mm. deep; plectenchymatous basal layer 20-30 μ thick; covering layer of epidermal wall and dark pseudoparenchyma 40-45 μ thick; hymenium 150-200 μ thick. Asci clavate, 150-200 x 24-30 μ, 8-spored, truncate rostriform at tip especially when immature. Paraphyses filiform, simple, 135-150 μ long, about 1 μ thick. Ascospores filiform clavate, 75-90 x 3-4 μ, surrounded by a gelatinous sheath 3.0-4.5 μ thick. Pycnidia epiphyllous, continuous along sinus of needle, more or less effused, 280-630 μ in width, dark brown after conidial discharge.

On Abietineae. *Abies alba* Mill.: Czechoslovakia; Denmark; France; Germany; Hungary; Italy; Sweden; Switzerland.

Type Locality: Vosges Mts. on *Pinus Picea* probably *P. Picea* L.

Distribution: Sweden to Central Europe.

Illustrations: Hartig, Wichtige Krankh. Waldbäume, pl. 6, fig. 18-25. 1874.—Tidskr. Skovbr. **12**:206, fig. 5 a, b, c. 1891.—Hilitzer, Vědecké Spisy Vyd. Českoslov. Akad. Zeměd. **3**: pl. 2, fig. 9, pl. 3, fig. 12, 15.

Exsiccati: Linhart, Fungi hungar. 65 (in part); Thümen, Myc. univ. 463 (in part); D. Saccardo, Myc. ital. 504; Sydow, Myc. germ. 27.

Other Specimens Examined. Herbarium J. S. Boyce. On *Abies alba*: 1630, Almindingen, Bornholm, Denmark.

Herbarium J. H. Faull. On *A. alba*, 7177, Munich, Germany.

In Europe only one species of the "nervisequious" type is recognized on *Abies* but it is apparent from the literature that this species includes not only the *Hypodermella nervisequia* type described in detail by Hartig (1874) but also another distinct species which the writer has designated under the name *Hypodermella lirelliformis*. *H. nervisequia* has also been reported frequently in America where it has likewise been considered to be but a single species. There is no evidence, according to the writer's interpretation, of its occurrence in America.

The broad dark colored pycnidia are sufficient to separate this species from the others of the "nervisequious" type.

Nevertheless it is very similar to *Hypodermella nervata* and *Hypodermella Abietis-concoloris* of North America and infection experiments should be performed in order to establish the validity of these American species.

25. **Hypodermella sulcigena** (Rostrup) Tubeuf in Bot. Centralbl. **61**:49 (1895).

Hypodermium sulcigenum Link, Sp. Pl. **6**(2):89 (1824).
Schizoderma sulcigenum Duby, De Candolle & Duby, Bot. Gall. **2**:885 (1830).
Hypoderma sulcigenum Rostrup in Tidskr. Skovbr. **6**:284 (1883).
Hypoderma pinicola Brunchorst in Bergens Mus. Aarbog, **8**:6 (1892).
Lophodermella sulcigena v. Höhnel in Ber. Deutsch. Bot. Ges. **35**:247 (1917).

Hysterothecia scattered on pale sordid areas, often on dead portions of living green needles, amphigenous, elliptical to elongate, 2-20 mm. long, 0.33-0.44 mm. wide; hysterothecia in cross section subhypodermal, 0.20-0.25 mm. deep; basal layer of delicate plectenchyma 27-33 μ thick at maturity, conspicuously thicker in earlier stages (up to 45-90 μ); covering layer of epidermis and hypodermis up to 30-35 μ thick, light brown pseudoparenchymatous covering tissue 22-38 μ thick; hymenium 100-120 μ thick. Asci clavate, 4- or 8-spored, 110-140 x 13-15 μ. Paraphyses simple, filiform, 100-120 μ long, 1 μ diameter. Ascospores clavate, tapering abruptly towards the base, hyaline, 27-35 x 4-5 μ, with a gelatinous sheath 3-4 μ thick.

On Abietineae. *Pinus mugo* Turra: Denmark; Scotland.—*Pinus mugo* var. *rostrata* Hoopes, Norway.—*Pinus sylvestris* L.: Denmark; Norway; Sweden.

Type Locality: Frederiksvaerk, Denmark on *P. sylvestris*.

Distribution: Scotland and Scandinavian region.

Illustrations: Tidskr. Skovbr. **6**:284, fig. 12 a, b, c. 1883.

Exsiccati: Rehm, Ascom. 1907.

Other Specimens Examined. Herbarium J. S. Boyce. On *Pinus mugo*: 1530, Beaufort, Scotland.—On *Pinus sylvestris*: 1621, near Frederiksborg, Zealand, Denmark, coll. E. Rostrup; 1622, Frederiksborg, Zealand, Denmark, coll. E. Rostrup.

Herbarium G. D. Darker. On *Pinus mugo* var. *rostrata*: 3325, near Bergen, Norway, coll. Ivar Jørstad.—On *P. sylvestris*: 3326,

Lier, Norway, coll. Ivar Jørstad; 3327, Bossekop, Norway, coll. Ivar Jørstad.

Hypodermella sulcigena is a destructive European parasite which has been described in detail by Rostrup (1883) and Lagerberg (1910). Rostrup considered *Hypodermium sulcigenum* Link the imperfect stage of *H. sulcigena.* Lagerberg, however, contended that *Hendersonia acicola* Tubeuf was the conidial stage. Wanin (1925) reported an outbreak of disease caused by *H. sulcigena* but he was unable to find *Hendersonia* in association with the perfect stage. From observations made in western America on the closely related species, *Hypodermella montivaga,* the writer believes that *Hendersonia* is merely a secondary fungus following up after the disease has been initiated by the other species. It is very probable that the same relation will be found to exist in Europe, because *Hendersonia* is an imperfect stage entirely different from any others known to be associated with Hypodermataceae.

Lind (1913) regarded Brunchorst's species, *Hypoderma pinicola,* as synonymous with *Hypodermella sulcigena.* More recently Wilson (1920) reported a fungus in Scotland which he believed was identical with *H. pinicola.* The writer has examined material similar to Wilson's collected by Boyce in Scotland. The original description of *H. pinicola* lacked ascus and spore measurements but insofar as it was complete it agreed in every respect with *H. sulcigena.* The material from Scotland, on the other hand, has long ascospores, almost filiform in shape and the hysterothecia are small and frequently laterally fused in marked contrast to the short clavate spores and separate sulcate hysterothecia of *H. sulcigena.* The writer has applied the name *Hypodermella conjuncta* to Wilson's species. The next species described, *Hypodermella montivaga,* is very closely related to *H. sulcigena* and further study may prove them identical.

26. **Hypodermella montivaga** (Petrak) Dearness in Mycologia, **16**:151 (1924).

Lophodermella montivaga Petrak in Petrak & Sydow in Ann. Myc. **20**:191 (1922).

Hysterothecia scattered, on sordid areas mostly terminal on one year old needles, discolored brown in lip region, waxy when

moist, 0.28-0.40 x 0.75-8.00 mm.; lips inconspicuous; hysterothecia in cross sectional view subhypodermal, 0.42-0.63 mm. wide (including triangular wedges of plectenchyma which extend under the epidermis at edges of hysterothecia), 0.22-0.25 mm. deep; basal plectenchyma 24-30 μ thick, becoming thicker along sides of hysterothecia (up to 40 μ); covering layer of epidermis and hypodermis 25-32 μ thick and colorless plectenchyma layer 30-33 μ thick; hymenium 108-150 μ thick. Asci elongated, clavate, 8-spored, 120-160 x 12-15 μ. Paraphyses simple, up to 150 μ long, 1 μ diameter, slightly swollen at tip. Ascospores clavate, hyaline, 40-50 x 3-4 μ, surrounded by a gelatinous sheath about 3-4 μ thick.

On Abietineae: *Pinus contorta* Douglas, Colorado, Idaho, Montana, Oregon, Wyoming.

Type Locality: Waha, Idaho on *P. contorta.*

Distribution: Southwestern Montana to Colorado and west to region of Mt. Hood, Oregon.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Pinus contorta*: 265 (in part), 347, 353, Government Camp, Ore., coll. G. D. Darker.

Herbarium J. S. Boyce. On *P. contorta*: 1487, Elkhorn, Colo., coll. G. G. Hedgcock; 1086, Waha, Idaho, coll. C. H. Shattuck; 1239, Yellowstone Nat. Park, Wyoming, coll. J. C. Evenden; 1397, Foxpark, Wyoming, coll. G. G. Hedgcock & Johnston; 1485, Foxpark, Wyoming, coll. G. G. Hedgcock.

Hypodermella montivaga was named by Petrak from American material but he made no mention of the striking similarity which this species bears to *Hypodermella sulcigena* of Europe. The points of distinction between the two species are very poorly defined at present. Since certain features in the development of the two species appear to be rather different, the writer has tentatively preferred to retain *H. montivaga* as a distinct species.

27. **Hypodermella arcuata,** sp. nov.

Hysterotheciis ellipticis amphigenis candidis 0.38-3.13 x 0.25-0.45 mm.; hysterotheciis in transversalis sectionis aspectu subhypodermalibus 210-260 μ profundis; tegente epidermidis hypodermidisque strato ad 30-37 μ crasso, tegente candidi pseudoparenchymatis strato 10-18 μ crasso in hysterothecii centro; basilari achroï plectenchymatis strato 15-30 μ crasso; hymenio 140-160 μ crasso. Ascis clavatis octosporis 110-160

x 14-18 μ. Paraphysibus simplicibus in apicibus parum afflatis 120-135 μ longis et 0.5-1.0 μ crassis. Ascosporis clavatis ad basin acute attenuatis hyalinis 42-50 x 4-6 μ, muco usque 6 μ crasso involutis.

In foliis *Pini Lambertianae* Dougl., ad Ashland, Jackson County, Oregon, mense Augusto, 1918, Herbarium J. S. Boyce, 304, P. D. Sergent legit.

Hysterothecia elliptical, amphigenous, concolorous with leaf surface when dry, orange brown and waxy when wet, 0.38-3.13 x 0.25-0.45 mm.; hysterothecia in cross section subhypodermal, 210-260 μ deep (open); covering layer of host tissue (epidermis and hypodermis) up to 30-37 μ thick; thin covering layer of fungal tissue of light colored pseudoparenchyma 10-18 μ thick in central region of hysterothecium; basal layer of colorless plectenchyma 15-30 μ thick extending laterally up the sides of hysterothecium; hymenium 140-160 μ thick. Asci clavate, 8-spored, 110-160 x 14-18 μ. Paraphyses simple, slightly swollen at tips, 120-135 μ long, 0.5-1.0 μ thick. Ascospores clavate, tapering acutely toward base, hyaline, 42-50 x 4-6 μ, with a gelatinous sheath up to 6 μ in thickness.

On Abietineae: *Pinus Lambertiana* Dougl., Oregon.

Type Locality: Ashland, Jackson County, Oregon on *P. Lambertiana,* August, 1918, Herbarium J. S. Boyce, 304, coll. P. D. Sergent.

Distribution: Known only from type locality.

Specimens Examined. Herbarium J. S. Boyce. On *P. Lambertiana*: 303, 304, 305, Ashland, Oregon, coll. P. D. Sergent.

Hypodermella arcuata is a very interesting species. It is the only member of the *Hypodermella sulcigena* group known on 5-needled pines. It resembles *H. sulcigena* and *Hypodermella montivaga* in many features but the ascocarp of *H. arcuata* is strongly arched above and does not extend deeply into the host tissue as in the other species.

Hypodermella arcuata is known only from three gatherings made at Ashland, Oregon. Studies on the pathogenicity of this species would be very illuminating since there is the possibility that it may simply be a form of *Hypodermella montivaga* or *Hypodermella sulcigena.*

28. **Hypodermella concolor** (Dearness), sp. nov.

Hypodermella montivaga (Petrak) Dearness f. *concolor* Dearness in Mycologia, **18**:242 (1926).

Hysterothecia at first seated on dead tawny areas which later fade to a pale buff, hysterothecia at first slightly darker than the leaf surface and more waxy in appearance, later concolorous with leaf surface, following the stomatal lines, at maturity forming shallow depressions, inconspicuous, amphigenous, 0.40-0.80 x 0.28-0.44 mm.; hysterothecia in cross section subhypodermal, 0.20-0.28 mm. deep; basal plectenchyma colorless, 10-15 μ thick; covering layer of epidermis and hypodermis 20-30 μ thick and colorless compact plectenchyma 10-15 μ thick, occasionally a layer of host parenchyma and fungus tissue up to 30 μ thick covers over the hysterothecium; hymenium 135-200 μ thick. Asci subcylindric, 8-spored, 120-225 x 15-17 μ, rarely (in fresh material) up to 21 μ broad. Paraphyses about as long as the asci, at maturity becoming variously expanded at the tips into spore-like proliferations. Ascospores clavate, the lower half tapering to an acute base, hyaline, 45-60 x 6-8 μ with a gelatinous sheath 2-3 μ in thickness.

On Abietineae. *Pinus Banksiana* Lamb., Ontario.—*Pinus contorta* Dougl., Colorado, Idaho, Montana, Wyoming.—*Pinus contorta* var. *latifolia* Rehder, Alberta, Saskatchewan.

Type Locality: Wyoming on *P. contorta.*

Distribution: Southern Alberta to Colorado and east to Northern Ontario.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Pinus contorta*: 62, Priest Lake, Idaho, coll. G. D. Darker.

Herbarium J. S. Boyce. On *P. contorta*: 1483, Rollinsville, Colo., coll. G. G. Hedgcock; 1743, Victor, Idaho, coll. C. C. Sherman; 1798, Sula, Mont., coll. A. L. Gibson; 1237, 1238, Sheep Creek, Mont.

Herbarium G. D. Darker. On *Pinus Banksiana*: 1473, 1480, 1492, 1552, 1643, 1679, 1686, 1704, 1705, 1764, 1776, 1777, 1778, 1779, 1780, 1781, 1782, 1783, 1784, 1785, 1831, 1994, 1995, 2057, 2137, 2224, Lake Timagami, Ont.—On *P. contorta* var. *latifolia*: 2187, Castlemount, Alta., coll. J. L. Van Camp; 1633, Cypress Hill Forest Reserve, Sask., coll. H. A. Parker.

Examinations of herbarium materials revealed that *Hypodermella concolor* is the commonly collected species of the "nervisequious" type in America. Its short colorless hystero-

thecia make it readily distinguishable in the field from *Hypodermella montivaga*. In cross section the hysterothecia of *H. concolor* are seen to be more deeply seated in the host tissue.

Infection experiments performed by the writer have established *Hypodermella concolor* as an extremely virulent pathogen. The artificially infected needles were pale pinkish buff (Ridgway, 1912) at the time of maturity of the hysterothecia. Earlier in the season they were tawny (R).

29. **Hypodermella conjuncta,** sp. nov.

Hysterotheciis numerosis avellaneis colore longitrorsum secus stomatum lineas aperientibus; hysterotheciis in tangentialis sectionis aspectu 0.50-3.75 mm. longis, 0.20-0.28 mm. latis, frequenter 2-4 hysterotheciis lateraliter connexis et lata fructificantiaque corpora usque 0.84 mm. lata et 0.14-0.18 mm. profunda subhypodermalia formantibus; basilari plectenchymate 10-30 μ crasso achroö; tegente pseudoparenchymatis epidermidisque hypodermidisque strato 45-60 μ crasso; pseudoparenchymate avellaneo colore, 15-24 μ crasso; hymenio 140-160 μ crasso. Ascis 110-160 x 15-16 μ, cylindricis fusiformibusque octosporis in apice acutatis. Paraphysibus simplicibus 135-150 μ longis et 1-2 μ crassis. Ascosporis hyalinis 75-90 x 3.0-3.5 μ, filiformibus clavatisque, muco 1.5-3.0 μ crasso involutis.

In foliis *Pini sylvestris* L., ad Beauly, Inverness-shire, Scotland, mense Iunio, 1925, Herbarium J. S. Boyce, 1528, J. S. Boyce legit.

Hysterothecia numerous on sordid areas mostly on terminal portions of green needles one year old or older, opening by a longitudinal slit along the stomatal lines; hysterothecia in plane sectional view 0.50-3.75 mm. long, 0.20-0.28 mm. wide, frequently 2-4 hysterothecia fused laterally making broad fruiting bodies up to 0.84 mm. wide, 0.14-0.18 mm. deep, subhypodermal; basal plectenchyma 10-30 μ thick, colorless, extending up sides of the hysterothecium, in the laterally confluent hysterothecia forming a sterile wall between the individual hysterothecia; covering layer of pseudoparenchyma, epidermis and hypodermis 45-60 μ thick, pseudoparenchyma light brown in color, 15-24 μ thick; hymenium 140-160 μ thick. Asci 110-160 x 15-16 μ, cylindric fusiform, 8-spored,

acutely pointed at tip. Paraphyses simple, 135-150 μ long, 1-2 μ thick, slightly swollen at tip. Ascospores 75-90 x 3.0-3.5 μ, filiform clavate, surrounded by a gelatinous sheath about 1.5-3.0 μ in thickness, hyaline.

On Abietineae: *Pinus sylvestris* L., Scotland.

Type Locality: Near Beauly, Inverness-shire, Scotland on *P. sylvestris*, June, 1925, Herbarium J. S. Boyce, 1528, coll. J. S. Boyce.

Distribution: Known only from central Scotland.

Specimens Examined. Herbarium J. S. Boyce. On *P. sylvestris*: 1528, 1529, near Beauly, Inverness-shire, Scotland.

As pointed out above, this species is described in detail by Wilson (1920) under the name *Hypoderma pinicola* Brunchorst. The material examined by the writer was not quite mature but otherwise it agreed in every way with that of Wilson.

The small laterally fused hysterothecia and elongated spores of *Hypodermella conjuncta* set it clearly apart from the other "sulcigenous" species.

30. **Hypodermella cerina**, sp. nov.

Hysterotheciis in sordidis aut cereis areis rubidorum affixorumque foliorum amphigenis 0.60-2.75 x 0.30-0.63 mm., folii superficiei concoloribus; hysterotheciis in transversalis sectionis aspectu subhypodermalibus 140-280 μ profundis; basilari plectenchymate 15-30 μ crasso achroö; tegente pseudoparenchymatis epidermidisque hypodermidisque strato 53-69 μ crasso, pseudoparenchymate candido 10-24 crasso; hymenio 180-225 μ crasso. Ascis octosporis fusiformibus 160-225 x 17-21 μ. Paraphysibus filiformibus 180-200 μ longis et 1-3 μ crassis, septis conspicuis. Ascosporis clavatis 68-78 x 3.0-3.5 μ, muco 3-5 μ crasso involutis.

In foliis *Pini contortae* Douglas, ad summum, Johnson's Pass, Eldorado County, California, mense Septembri, 1929, Arnold Arboretum, Pathological Herbarium, 724, G. D. Darker legit.

Hysterothecia more or less aggregated on sordid or waxy spots on reddish-brown colored, attached needles, amphigenous, 0.60-2.75 x 0.30-0.63 mm., concolorous with leaf surface; hysterothecia in cross sectional view subhypodermal, lenticular in outline when closed, 140-280 μ deep; basal plec-

tenchyma 15-30 μ thick, colorless, continuous laterally in a thicker layer up the sides of the hysterothecia; covering layer (light colored pseudoparenchyma, epidermis and hypodermis) 53-69 μ thick, pseudoparenchyma 10-24 μ thick; hymenium 180-225 μ thick. Asci 8-spored, fusiform, 160-225 x 17-21 μ, tapering acutely towards the rounded tip. Paraphyses filiform, 180-200 μ long, 1-3 μ thick, slightly swollen at tip, septa conspicuous. Ascospores clavate, 68-78 x 3.0-3.5 μ, surrounded by a gelatinous sheath 3-5 μ thick.

On Abietineae: *Pinus contorta* Douglas, California.—*Pinus ponderosa* Douglas, California.

Type Locality: Near Summit, Johnson's Pass, Eldorado County, California, September, 1929, Arnold Arboretum, Pathological Herbarium, 724, coll. G. D. Darker.

Distribution: Known only from California.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Pinus contorta*: 698, Phillips, Eldorado County, Cal., coll. G. D. Darker; 724 (Type), near Summit, Johnson's Pass, Eldorado County, Cal., coll. G. D. Darker.

Herbarium Office of Forest Pathology, San Francisco, Cal. On *Pinus ponderosa*: M(2)D35 (in part), Modoc National Forest, Cal., coll. E. P. Meinecke.

Hypodermella cerina is similar in general appearance to *Hypodermella concolor*. Its hysterothecia, however, are more lens-shaped in cross section and are less deeply seated in the host tissue. The asci are considerably broader in *H. cerina* and its ascospores are more nearly filiform than those of *H. concolor*. Both species are strongly parasitic and in some localities control measures would be warranted.

ELYTRODERMA, gen. nov.

Hysterothecia innata erumpentiaque, atra, brevia ellipticaque usque linearia, longitudinali incisura aperientia, in substratum penitus extendentia, hymenium concavum. Asci fusiformes clavatique, octospori. Paraphyses simplices, filiformes. Ascospori longi, fusiformes, biloculares, conspicua gelatinosa vagina circumdati. Pycnidia simplicia, stratum conidiophororum applanatum, cum minutis bacillaribusque conidiis. Species typica: *Elytroderma deformans* (Weir) Darker.

Hysterothecia innate erumpent, dark, short elliptical to

linear, opening by a longitudinal slit, extending deeply into substratum, hymenium concave. Asci fusiform clavate, 8-spored. Paraphyses simple, filiform. Ascospores long, fusiform, 2-celled, surrounded by a conspicuous gelatinous sheath. Pycnidia simple, conidiophore layer applanate, with minute bacillar conidia. Type species: *Elytroderma deformans* (Weir) Darker.

31. **Elytroderma deformans** (Weir), comb. nov.

Hypoderma deformans Weir in Jour. Agric. Res. **6**:277 (1916).

Hysterothecia amphigenous, on dead needles or on browned tips or spots on living, green, one year old needles, scattered or in more or less constricted series, 1-7 mm. long, subepidermal in the darkened central region but becoming subhypodermal at the margins of the pustules; hysterothecia in cross section 350-450 μ wide, 175-260 μ deep (closed); basal and lateral plectenchyma layer 25-32 μ thick; dark covering layer (including overarched epidermis) 50-80 μ thick, 210-250 μ wide, forming a layer which extends from one stomatal line to an adjoining line, opening between the stomatal lines by a longitudinal fissure; hymenium 180-245 μ thick. Asci 8-spored, fusiform, 140-240 x 30-45 μ, at maturity becoming somewhat distorted, thus accounting in part for the great variation in width. Paraphyses filiform, about 2 μ in width, swollen at tips, about as long as the asci, 2 to 3-septate. Ascospores 1-septate at maturity, cylindric or slightly spindle-shaped, often somewhat curved, 90-118 x 6-8 μ, surrounded by a gelatinous sheath 6-10 μ in thickness. Pycnidia concolorous with the leaf surface, appearing as small blisters up to 1.2 mm. long, subepidermal, in cross section 150-280 μ in width, 35-55 μ deep (including overlying epidermis). Conidiophores 12-15 μ long, arising from a basal layer 1-3 cells thick, simple, basal portion tipped by a slender filament from which the conidia are pinched off terminally. Conidia hyaline, bacillar, 0.4-0.6 x 4-6 μ.

On Abietineae. *Pinus Banksiana* Lamb., Ontario.—*Pinus contorta* Dougl.: Oregon; British Columbia.—*Pinus echinata* Mill., Georgia.—*Pinus edulis* Engelm., Colorado.—*Pinus Jeffreyi* Murr., California.—*Pinus ponderosa* Dougl.: California, Idaho, Montana, Oregon, Washington; British Columbia.

TYPE LOCALITY: Sumpter, Oregon on *P. ponderosa.*

DISTRIBUTION: British Columbia to California and east to Colorado with two isolated stations in Georgia and Northern Ontario.

ILLUSTRATIONS: Jour. Agric. Res. **6**:278, fig. 1, 279, fig. 2, 280, fig. 3, 281, fig. 4, pl. 32, fig. 1-3. 1916.

EXSICCATI: Bartholomew, Fungi Columb. 5028.

OTHER SPECIMENS EXAMINED. Arnold Arboretum, Pathological Herbarium. On *Pinus Jeffreyi,* 737, near Camp Richardson, Lake Tahoe, Cal., coll. G. D. Darker.

Herbarium J. S. Boyce. On *Pinus contorta*: 829, Lookout Mt., Hood River County, Ore.—On *Pinus echinata*: 1491, Elijay, Gilpin County, Georgia, coll. G. G. Hedgcock.—On *Pinus edulis*: 1496, Mancos, Colo., coll. E. Bethel & E. B. Payson.—On *Pinus ponderosa*: 301, Goosenest Mt., Siskiyou County, Cal.; 300, Pilgrim Creek Nursery, Siskiyou County, Cal.; 302, Crocker's Resort, Tuolomne County, Cal.; 1468, Priest River, Idaho, coll. J. R. Weir; 1256, Priest River, Idaho; 299, Coeur d'Alene, Idaho, coll. J. R. Weir; 1492, East Fork Bitter Root, Ravalli County, Montana, coll. G. G. Hedgcock; 727, Prairie City, Grant County, Ore.; 1050, Loomis, Wash.; 1255, Kelowna, B. C.

Herbarium J. H. Faull. On *Pinus Banksiana*: 6828, Lake Timagami, Ont.

Herbarium Office of Forest Pathology, San Francisco, Cal. On *P. Jeffreyi*: Ta(1)K102, near Cisco, Placer County, Cal., coll. E. P. Meinecke, J. S. Boyce, A. S. Rhoads & H. G. Lachmund; ShD4, Sisson Tavern Park, Shasta County, Cal., coll. E. P. Meinecke; SeN1001, near Hot Springs, Sequoia National Forest, Cal., coll. J. G. Lang; LaE63, Chester, Plumas County, Cal., coll. E. P. Meinecke; Brit. Col. Kelowna P1, Kelowna, B. C., coll. E. P. Meinecke.

Weir (1916) described the life history of this organism in detail. His investigations on pathogenicity include the only well-controlled experiments reported in the literature of the Hypodermataceae.

Elytroderma deformans has been collected by Dr. J. H. Faull in Northern Ontario on *Pinus Banksiana.* Heretofore this species has only been obtained once east of the Rocky Mountains. The Ontario material was of the type found on *Pinus contorta.* No witches' brooms were present. Brooms have been reported only on *Pinus ponderosa* and *Pinus Jeffreyi.* On the latter host the writer has observed stands of young trees in the neighborhood of Lake Tahoe, California, in which many of the smaller trees 5 to 6 feet in height were completely converted into loose, somewhat flat-topped brooms. The branches were stunted and the internodes were much

shortened and swollen. Many young trees had succumbed to the attack.

Elytroderma deformans is very close to the genus *Hypodermella* in many characters but its two-celled spores are sufficiently striking to set it off in a separate genus. In cross section the hysterothecium resembles that of *Hypodermella medusa* very closely. Even in early stages, however, *E. deformans* can be recognized by a peculiar cell-like structure which appears in the young developing ascus.

LOPHODERMIUM Chevallier, Fl. Paris, **1**:435 (1826).

Lophoderma Chevallier in Jour. Phys. **94**:31 (1822).
Aporia Duby (in part) in Mém. Soc. Phys. Hist. nat. Genève, **16**:51 (1861).
Lophodermina von Höhnel in Ber. Deutsch. Bot. Ges. **35**:418 (1917).
Lophodermellina von Höhnel in Ber. Deutsch. Bot. Ges. **35**:419 (1917).
Scolecodothis Miles in Mycologia, **18**:165 (1926).

Hysterothecia innate erumpent, mostly elliptical, occasionally elongated, dull to shining black, opening at first by a longitudinal slit, hymenium mostly flat. Asci narrowly cylindric or cylindric clavate, 8-spored or with 4 spores aborted, mostly subacute at apex. Paraphyses simple, hooked or coiled at tips, frequently swollen at tips and at maturity sometimes branching. Ascospores simple, filiform, hyaline, fasciculate, unicellular, surrounded by a thin gelatinous sheath. Pycnidia simple, conidiophore layer applanate, conidia minute, bacillar. Type species: *Lophodermium arundinaceum* (Schrader ex Fries) Chevallier.

KEY TO SPECIES OF LOPHODERMIUM

a. Hysterothecia with well defined primordium of slit...b.
  b. Hysterothecia subcuticular...c.
    c. Hysterothecia on Juniperus .....32. *L. juniperinum*
    c. Hysterothecia on Cedrus .....33. *L. cedrinum*
  b. Hysterothecia subepidermal; on Pinus .....34. *L. pinastri*
a. Hysterothecia without conspicuous primordium of slit...d.
  d. Hysterothecia subcuticular...e.
    e. Pycnidia conspicuous...f.
      f. Pycnidia shining black...g.
        g. On Larix .....35. *L. laricinum*
        g. On Pinus .....36. *L. nitens*

f. Pycnidia yellow, orange or brown; on Abies
37. *L. uncinatum*
e. Pycnidia inconspicuous or lacking...h.
h. On Abies .....38. *L. autumnale*
h. On Thuja .....39. *L. Thuyae*
d. Hysterothecia not subcuticular...i.
i. Hysterothecia intraepidermal...j.
j. Hysterothecia short, elliptical...k.
k. On Abies...l.
l. Associated with a "nervisequious" species
40. *L. consociatum*
l. Not associated with another species
41. *L. lacerum*
k. On Picea .....42. *L. Piceae*
j. Hysterothecia elongated; on Picea...m.
m. Pycnidia conspicuous .....43. *L. macrosporum*
m. Pycnidia inconspicuous .....44. *L. filiforme*
i. Hysterothecia subepidermal...n.
n. In centre subhypodermal; on Pinus ..45. *L. durilabrum*
n. In centre subepidermal...o.
o. Pycnidia conspicuous; on Picea .....46. *L. crassum*
o. Pycnidia inconspicuous...p.
p. On Abies .....47. *L. decorum*
p. On Chamaecyparis .....48. *L. Chamaecyparisii*

32. **Lophodermium juniperinum** (Fries) de Notaris in Giorn. Bot. Ital. **2**:46 (1847).

Hysterium juniperinum Fries, Observ. Myc. **2**:355 (1818).—Cooke, Handb. Brit. Fungi, **2**:763 (1871).
Hysterium Juniperi Greville, Scott. Crypt. Fl. **1**: tab. 26 (1823).
Hysterium Pinastri β *Juniperinum* Fries, Syst. Myc. **2**:588 (1823).
Lophodermium juniperinum f. *Cupressi thyoidis* Saccardo in Michelia, **2**:570 (1882).
Lophodermium Sabinae Fautrey in Rev. Mycol. **13**:169 (1891).

Hysterothecia scattered, amphigenous, elliptical, variable in size, 0.25 x 0.35 up to 0.45 x 0.90 mm., shining black, opening by a narrow slit; hysterothecia in cross section subcuticular, lips bounded by a row of papillate, hyaline cells which dovetail into one another; 150-170 μ deep; basal plectenchyma 7-12 μ thick, extending laterally up sides of hysterothecium; covering layer of cuticle and dark pseudoparenchyma 35-45 μ

thick in lip region; hymenium 110-130 μ thick. Asci cylindric to somewhat fusiform, 8-spored, 110-130 x 15-17 μ. Paraphyses filiform, strongly hooked at tips, 2 μ thick, 115 μ long. Ascospores fasciculate, filiform, hyaline, often multiguttulate, 70-90 x 2-3 μ, surrounded by a mucous sheath about 3 μ in thickness.

On Abietineae. *Chamaecyparis* sp., Germany.—*Chamaecyparis thyoides* (L.) BSP., New Jersey.—*Juniperus* sp., Ireland.—*Juniperus chinensis* L. var. *Sargenti* Henry, Massachusetts.—*Juniperus communis* L.: Colorado, Iowa, New York, Washington; Belgium; Czechoslovakia; Denmark; England; Germany; Italy; Scotland.—*Juniperus communis* var. *depressa* Pursh: Maine, Massachusetts, New Hampshire; Ontario.—*Juniperus horizontalis* Moench.: Massachusetts; Ontario.—*Juniperus Sabina* L.: Denmark; France; Poland; Switzerland.—*Juniperus communis* var. *montana* Ait.: Oregon; Washington.—*Juniperus squamata* Buch.-Ham., Denmark.—*Juniperus virginiana* L.: Massachusetts, New York; Ontario; Denmark.—*Libocedrus decurrens* Torr., California, Oregon.

Type Locality: Locality not given by Fries. On *Juniperus*.

Distribution: Western Europe and temperate North America.

Illustrations: Greville, Scott. Crypt. Fl. 1: pl. 26, fig. 1-4. 1823.—Hilitzer, Vědecké Spisy Vyd. Českosl. Akad. Zeměd. 3:15, fig. 4, 1929.

Exsiccati: Cooke, Fungi Brit. exsicc., 1st Ser. 395; Fuckel, Fungi rhen. 735; Krieger, Fungi sax. 382; Linhart, Fung. hung. 153; Rehm, Ascom. 128 b; Roumeguère, Fungi Gall. exsicc. 3545; Roumeguère, Fungi selecti exsicc., 5863; Saccardo, Mycoth. ital. 871; Saccardo, Myc. Veneta, 950; Siemaszko, Fungi Bialow. exsicc. 15; Sydow, Myc. germ. 1600.

Other Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Juniperus communis* var. *montana*: 151, Government Camp, Ore., coll. G. D. Darker.—On *Libocedrus decurrens*, 435, Prospect, Ore., coll. G. D. Darker; 574, Sucker Creek, Josephine County, Ore., coll. G. D. Darker; 409, Ashland, Ore., coll. G. D. Darker.

Herbarium J. S. Boyce. On *Juniperus communis*: 1514, Steamboat Springs, Colo., coll. G. G. Hedgcock; 315, Sol Duc Hot Springs, Wash.; 1799, Almindingen, Bornholm, Denmark.—On *Juniperus virginiana*: 1642, Wilmington, N. Y.—On *Libocedrus decurrens*: 581, Massack, Cal.

Herbarium K. S. Chester. On *Juniperus communis* var. *depressa*: 723, near Walpole, Mass., coll. K. S. Chester & G. D. Darker; 319, New Ipswich, N. H.

Herbarium J. H. Faull. On *J. communis*: 8046, Prov. Brandenburg, Germany, coll. H. W. Wollenweber.—On *J. communis* var. *depressa*: 9168, near Cambridge, Mass.

Herbarium J. Ehrlich. On *J. communis*: 95, Pottersville, N. Y.

Herbarium Office of Forest Pathology, U. S. Dept. of Agriculture. On *J. communis* var. *depressa*: 2338, Petersham, Mass., coll. J. R. Hansbrough.

Herbarium G. D. Darker. On *Juniperus chinensis* var. *Sargenti*: 3574, 3613, Arnold Arboretum, Jamaica Plain, Mass.—On *J. communis* var. *depressa*: 3558 (in part), near Old Orchard Beach, Me.; 3612, Stoneham, Mass.; 1085, Lake Timagami, Ont., coll. J. H. Faull; 1167, Lake Timagami, Ont., coll. W. R. Watson; 1115, 1166, 1236, 1258, 1376, 1438, 1815, Lake Timagami, Ont.; 2033, Honey Harbor, Ont.—On *Juniperus horizontalis*: 3618, Arnold Arboretum, Jamaica Plain, Mass.; 2180, McGregor Bay, District of Manitoulin, Ont., coll. E. H. Bensley.—On *J. virginiana*: 3368, Canton, Mass., coll. J. H. Faull; 2036, Honey Harbor, Ont.

Lophodermium juniperinum is not of economic significance. Although the hysterothecia are frequently developed in great profusion there is no evidence of parasitism. It is the only species known on *Juniperus;* but on *Chamaecyparis* another species, *Lophodermium Chamaecyparisii,* has also been reported. The latter species is subepidermal and is therefore easily distinguished from *L. juniperinum* which is subcuticular.

Ascospore germination is frequently marked by the production of knee-like bends at the points from which the germ tubes are given off from the spores.

33. **Lophodermium cedrinum** Maire in Bull. Soc. Hist. Nat. Afr. Nord, 8:174 (1917).

Labrella cedrina Durieu & Montagne, L'Exploration scientifique de l'Algérie, Cryptogamie, 1:599 (1849).

Hysterothecia scattered on fallen needles, shining black, elliptical, amphigenous, 0.30-0.69 x 0.5-1.0 mm.; disc flat; lips conspicuous, dark; hysterothecia in cross section subcuticular, 0.33-0.41 mm. deep; basal plectenchyma 24-33 μ thick, extending laterally up the sides of the hysterothecium in a thin layer; covering layer of cuticle and brown pseudoparenchyma 75-90 μ thick at centre, becoming abruptly thinner laterally and extending slightly beyond the cavity of the hysterothecium, lips bounded by a layer of papillate colorless cells; hymenium 180-250 μ thick. Asci elongate clavate, 8-spored, 165-250 x 15-18 μ. Paraphyses abundant, filiform, about 1 μ in thickness, variously curled at tips, often swollen terminally to 2.0-2.5 μ. Ascospores filiform, hyaline, fasciculate, often

spirally coiled near tip of ascus, 110-165 x 2.0-2.5 μ. Pycnidia subcircular, black, oblong or linear, convex, shining. Conidiophores filiform, densely aggregated, 10-12 x 0.8-1.0 μ. Conidia bacillar, hyaline, 4-6 x 0.7-1.0 μ.

On Abietineae: *Cedrus atlantica* Manetti, French West Africa (Mauretania), Algiers.

Type Locality: Mauretania on *C. atlantica.*

Distribution: Atlas Mts. in northwest Africa.

Illustrations: Dur. & Mont., Fl. Alg. **1**: pl. 27, fig. 7, 1849.

Specimen Examined. Herbarium Réné Maire. On *Cedrus atlantica*: 4951, near Teniet-el-Had, Algiers.

Lophodermium cedrinum is the cause of needle cast of *Cedrus* but to date this disease has not been reported in America. The hysterothecia of *L. cedrinum* are very similar to those of *Lophodermium pinastri* but are subcuticular in position.

34. **Lophodermium pinastri** (Schrader ex Fries) Chevallier, Flore de Paris, **1**:436 (1826).

Hysterium pinastri Schrader in Schrad. Jour. Bot. **2**:69 (1799).—Fries, Syst. Myc. **2**:587 (1823).
Hysterium limitatum Wibel, Prim. Fl. Werth. 329 (1799).
Hypoderma pinastri De Candolle, Fl. Franç. **2**:305 (1805).
Hypodermium sparsum Link, Sp. Plant. **6**(2):88 (1824).
Leptostroma pinastri Desmazières in Ann. Sc. Nat. Ser. 2, **19**:338 (1843).
Aporia obscura Duby in Mém. Soc. Phys. Hist. Nat. Genève, **16**:51 (1861).
Depazea linearis Rostrup in Tidsskr. Skovbr. **6**:260 (1883).
Schizothyrium obscurum Saccardo, Syll. Fung. **2**:725 (1883).
Lophodermium baculiferum Mayr, Die Waldungen von Nordamerika, 313 (1890).
Gloeosporium Pini Oudemans in Nederl. Kruidkund. Arch. ser. 3, **2**:754 (1902).
Lophodermellina pinastri von Höhnel in Ann. Myc. **15**:311 (1917), tantum quoad nomen.
Scolecodothis pinicola Miles in Mycologia, **18**:165 (1926).
Lophodermium australe Dearness in Mycologia, **18**:242 (1926).
Lophodermium Laricis Dearness in Mycologia, **18**:243 (1926).

Hysterothecia scattered, amphigenous, elliptical, dull to shining black, 0.90-1.50 x 0.32-0.70 mm., opening widely by a longitudinal slit; lips conspicuous; hysterothecia in cross sec-

tion subepidermal except in lip region, 0.17-0.35 mm. deep; lips bounded by a row of colorless papillate cells along line of dehiscence; basal layer of plectenchyma colorless, 15-20 μ thick; covering layer pseudoparenchymatous, dark, 36-42 μ thick; hymenium 120-140 μ thick. Asci at first cylindric, becoming at maturity somewhat clavate and stipitate, apex rostriform, 8-spored, 120-150 x 12-13 μ. Paraphyses filiform, clavate, hooked at apex, at maturity often budding out at the swollen tips, 110-125 μ long, 1.5-2.0 μ thick. Ascospores filiform, when young often coiled spirally at the upper end of ascus, 85-140 x 1.5-2.0 μ, enveloped by a gelatinous sheath about 2 μ thick. Pycnidia subepidermal, 300-500 x 85-100 μ. Conidia bacillar, 8.0-9.5 x 0.4-0.5 μ.

On Abietineae. *Pinus* sp., Japan.—*Pinus albicaulis* Engelm., Oregon.—*Pinus Armandi* Franch., Massachusetts.—*Pinus attenuata* Lemmon, Oregon.—*Pinus Banksiana* Lamb.: Michigan, Minnesota; Ontario, Quebec.—*Pinus contorta* Dougl.: California, Oregon, Wyoming; British Columbia; Denmark.—*Pinus contorta* var. *latifolia* Rehder, Alberta.—*Pinus echinata* Mill., Arkansas.—*Pinus excelsa* Wall., India.—*Pinus Jeffreyi* Murr., California, Washington.—*Pinus koraiensis* Sieb. & Zucc.: Massachusetts; Jugoslavia.—*Pinus monticola* Dougl. ex Lamb., Massachusetts.—*Pinus mugo* Turra: Massachusetts; Denmark; Germany.—*Pinus mugo* var. *rotundata* Hoopes, Germany.—*Pinus nigra* Arnold, Denmark.—*Pinus nigra* var. *austriaca* Aschers. & Graebn.: Oregon; Ontario; Italy.—*Pinus nigra* var. *cebennensis* Rehder, Denmark.—*Pinus parviflora* Sieb. & Zucc., California, Massachusetts.—*Pinus Pinaster* Ait., Denmark.—*Pinus ponderosa* Dougl., California, Idaho, Massachusetts, Montana, Oregon, Pennsylvania, Washington, Wyoming.—*Pinus radiata* D. Don: California; New Zealand.—*Pinus resinosa* Ait.: Maine, Massachusetts, New Hampshire; Ontario, Quebec.—*Pinus rigida* Mill.: Maine, Massachusetts, Pennsylvania; Denmark; Germany.—*Pinus sabiniana* Dougl., California.—*Pinus sylvestris* L.: Massachusetts; Quebec; Denmark; Germany; Norway; Russia; Scotland; Sweden.—*Pinus Strobus* L.: Maine, Massachusetts; Ontario; Germany.—*Pinus Taeda* L., Louisiana, Mississippi, North Carolina.

Type Locality: Locality not given by Fries. On *P. sylvestris*.

Distribution: Widely distributed on Pinus species.

Illustrations: Arb. Biol. Abth. Kaiserl. Ges. **2**(1): pl. 1, fig. 1-11, pl. 2, fig. 1-24, pl. 4, fig. 1-13, pl. 5-7. 1901,—Greville, Scot. Crypt. Fl. **1**: pl. 60, fig. 1-4. 1823,—Schrad. Jour. Bot. **2**: pl. 3, fig. 4. 1799,—Tidskr. Skovbr. **6**:259, fig. 6, 260, fig. 7 a, b, 261, fig. 8-9. 1883; 12:203, fig. 4 a. 1891,—Zeitschr. Forst- u. Jagdw. **4**: pl. 4, fig. 1-8. 1911.

Exsiccati: Cooke, Fungi Brit. exsicc., 396; Krieger, Fungi sax.

383, 1170, 1171; Petrak, Mycoth. carpat., 20; Rabenhorst, Fungi europ. 371, 1443, 1922; Ravenel, Fungi car. 1:40; Saccardo, Mycoth. ital. 506; Sydow, Myc. germ, 1931; Sydow, Myc. march. 1376, 2360; Zopf & Sydow, Myc. march. 93.

Other Specimens Examined. Arnold Arboretum, Pathological Herbarium, coll. G. D. Darker. On *Pinus albicaulis,* 319, Mt. Hood, near Government Camp, Ore.—On *Pinus attenuata,* 509, Oregon Caves, Ore.—On *Pinus contorta*: 352, 363, Government Camp, Ore.; 418, Crater Lake, Ore.—On *Pinus Jeffreyi*: 725, Fallen Leaf Lake, Eldorado County, Cal.; 736, Camp Richardson, Lake Tahoe, Cal.—On *Pinus parviflora*: 657, Golden Gate Park, San Francisco, Cal.—On *Pinus ponderosa*: 682, Placerville, Cal.; 65, Coolin, Priest Lake, Idaho; 571, Grayback Creek, Josephine County, Ore.; 510, Oregon Caves, Ore.; 440, Prospect, Ore.—On *Pinus radiata*: 658, Golden Gate Park, San Francisco, Cal.—On *Pinus sabiniana*: 684, Placerville, Cal.

Herbarium J. S. Boyce. On *P. attenuata*: 629, Emigrant Camp, Lane County, Ore.—On *P. contorta*: 326, Cisco, Cal., coll. J. S. Boyce, H. G. Lachmund & A. S. Rhoads; 327, Bray, Cal.; 726, Bates, Ore.; 1146, Waldport, Ore.; 1054, New Westminster, B. C.—On *P. Jeffreyi*: 328, Wind River Nursery, Skamania County, Wash.; 313 (in part), Cisco, Cal.—On *Pinus nigra* var. *austriaca*: 805 (in part), Washington County, Ore.—On *P. ponderosa*: 334, Nevada City, Cal.; 335, Massack, Cal.; 826, Friend, Ore.; 465, Gulers, Wash.—On *P. radiata*: 340 (in part), Golden Gate Park, San Francisco, Cal.—On *P. Sabiniana*: 314, Weaverville, Cal.—On *Pinus sylvestris*: 1531, Kelso, Scotland; 1532, Glentress, Scotland.

Herbarium K. S. Chester. On *Pinus koraiensis*: 257, Arnold Arboretum, Jamaica Plain, Mass.—On *Pinus resinosa*: 525, Lake Winnepesaukee, N. H.

Herbarium J. H. Faull. On *Pinus Banksiana*: 6557, Kimberly, Minn., coll. H. B. Ayres; 5100, 6547, 6598, Lake Timagami, Ont.; 8622, Proulx, Que.—On *Pinus contorta* var. *latifolia*: 7521, Mercoal, Alta., coll. W. R. Watson; 7522, coll. K. G. Fensom.—On *P. koraiensis*: 8843, Arnold Arboretum, Jamaica Plain, Mass.—On *P. resinosa*: 9304, Provincial Forest Nursery, St. Williams, Ont.; 6548, Lake Timagami, Ont.; 8623 (in part), 8624 b, Proulx, Que.—On *Pinus rigida*: 7509, 7510, near Boston, Mass.—On *P. sylvestris*: 8048, Zehlendorfer Forest, Germany, coll. H. W. Wollenweber.—On *Pinus Strobus*: 8801, Cupsuptic, Me.

Herbarium Office of Forest Pathology, San Francisco, Cal. On *P. ponderosa*: M(2)D35 (in part), Modoc National Forest, Cal., coll. E. P. Meinecke.

University of Michigan Herbarium. On *P. Banksiana*: Isle Royale, Mich., coll. A. Povah.

Herbarium G. D. Darker. On *Pinus Armandi*: 2494, 2503, 3619, Arnold Arboretum, Jamaica Plain, Mass.—On *P. Banksiana*: 2201, near Sault Ste. Marie, Ont., coll. J. H. Faull; 1882, Elsas, Ont.,

coll. J. H. Faull; 1124, Lake Wasacsinagama, Timagami Forest Reserve, Ont.; 1101, 1245, 1251, 1278, 1301, 1381, 1392, 1399, 1446, 1467, 1488, 1564, 1620, 2222, Lake Timagami, Ont.—On *Pinus echinata*: 3463, Polk County, Arkansas, coll. P. V. Siggers.—On *P. koraiensis,* 2448, 2491, 2492, 2501, 3615, Arnold Arboretum, Jamaica Plain, Mass.—On *Pinus monticola*: 2502, 3606, Arnold Arboretum, Jamaica Plain, Mass.—On *Pinus mugo*: 2500, Arnold Arboretum, Jamaica Plain, Mass.—On *P. nigra* var. *austriaca*: 1916, Toronto, Ont.—On *P. parviflora*: 2449, 3611, Arnold Arboretum, Jamaica Plain, Mass.—On *P. ponderosa*: 3391, 3522, Arnold Arboretum, Jamaica Plain, Mass.—On *P. resinosa*: 3560, near Old Orchard Beach, Me.; 3378, Hamilton, Mass.; 2034, Honey Harbor, Ont.; 1090, 1107, 1324, 1331, 1364, 1395, 1499, 2097, 2220, Lake Timagami, Ont.—On *P. rigida*: 3561, near Old Orchard Beach, Me.; 2445, Gloucester, Mass.; 3527, Rockport, Mass.; 3379, 3485, Hamilton, Mass.—On *P. sylvestris*: 3582, Norway, coll. Agnar Barth.—On *P. Strobus*: 2213, Cupsuptic Lake, Me., coll. H. I. Baldwin; 3614 (in part), Sudbury, Mass., coll. A. Cutting; 2216, Lake Timagami, Ont.—On *Pinus Taeda*: 3360, 3458, Bogalusa, La., coll. P. V. Siggers; 3452, Durham, N. C., coll. F. A. Wolf.

Opinions regarding the parasitism of *Lophodermium pinastri* vary greatly. Arguments have been put forth pro and con, but to date no satisfactory conclusions have been reached. Under favorable climatic conditions *Lophodermium pinastri* may cause serious injury in nurseries and sometimes in the forest. Hartley (1913) advanced the suggestion that the practice of establishing nurseries in forests, especially forests of the same species as the nursery stock, may be responsible in part for the serious losses suffered in Europe. Thus far, however, under carefully controlled conditions no one has succeeded in producing artificial infection with any marked degree of success.

Lophodermium pinastri occurs everywhere on Pines, and on some species very slight morphological distinctions can be noted, but there seems to be no justification at present for separating any of these forms as new species. They appear to be merely host variations such as have been observed also in *Lophodermium Piceae.* It is quite possible, however, that strains of this fungus, differing in virulence, also occur in nature. In Maine a form on *Pinus Strobus* has been observed in nurseries by Dr. J. H. Faull.

Summaries of the important literature and details in the life history of *Lophodermium pinastri* are to be found in the pub-

lications of Tubeuf (1901, 1910), Haack (1911), Lagerberg (1914), and Hagem (1928).

35. **Lophodermium laricinum** Duby in Mém. Soc. Phys. Hist. Nat. Genève, **16**:46 (1861).

Leptostroma laricinum Fuckel, Symb. Myc. 256 (1869).

Hysterothecia scattered, amphigenous, elliptical, strongly arched at maturity, shining black, dehiscing by a narrow slit, 0.50-0.60 x 0.23-0.40 mm.; lips inconspicuous; hysterothecia in cross section subcuticular, 0.18-0.26 mm. deep; basal plectenchyma 15-30 μ thick, extending laterally up sides of hysterothecium, the lateral tissue of parallel plectenchymatous filaments 9-18 μ thick; covering layer of dark pseudoparenchyma 15-25 μ thick, with a thin area foreshadowing the longitudinal slit; hymenium 100-120 μ thick. Asci at first cylindrical, at maturity elongated basally and appearing clavate, rostriform, 8-spored, 100-125 x 9-11 μ. Paraphyses filiform, about 1 μ thick, hooked and slightly swollen at tips, hyaline, 100 μ long. Ascospores filiform, hyaline, 80-115 x 1.5-2.0 μ, with a gelatinous sheath about 1 μ in thickness. Pycnidia subcuticular, almost circular, 120-200 x 70-150 μ, shining black. Conidia hyaline, bacillar, 4.0-4.7 x 0.7-0.9 μ.

On Abietineae. *Larix* sp., Japan.—*Larix decidua* Mill.: Austria; Italy; Switzerland.—*Larix laricina* (Dur.) Koch, Ontario, Quebec.

Type Locality: "Ad radices orientales Alpium Pedemontii" on Larix.

Distribution: Central Europe, Northern Ontario and Quebec.

Illustrations: Arb. Biol. Abth. Kaiserl. Gesundh. **2**(1): pl. 3, fig. 11-12. 1901.

Exsiccati: Fuckel, Fungi rhen. 743; Rabenhorst, Fungi europ. 158; Rehm, Ascom. 1751; Saccardo, Myc. ital. 505.

Other Specimens Examined. Herbarium J. H. Faull. On *L. laricina*: 5984, Long Lake, 20 mi. N. E. Nédelec, Que.; 7170, Otter, Ont.

Herbarium G. D. Darker. On *L. laricina*: 1113, 1276, 1309, 1316, 1322, 1518, 1556, Lake Timagami, Ont.

Lophodermium laricinum has been collected in abundance in Northern Ontario on fallen larch needles in sphagnum bogs. One year is required in the life cycle of this species. In Northern Ontario pycnidia develop during the month of May on the fallen needles and these are followed by hysterothecia which mature in July.

36. **Lophodermium nitens,** sp. nov.

Hysterotheciis plane delimitatis ellipticis atronitidis, longitudinali fissura anguste aperientibus, 0.60-0.85 x 0.35-0.49 mm.; hysterotheciis in transversalis sectionis aspectu subcuticularibus 0.15-0.25 mm. profundis; basilari plectenchymate 23-30 μ crasso; tegente atri pseudoparenchymatis cuticulaeque strato 15-20 μ crasso in centro, 27-37 μ crasso in latere; hymenio 110-120 μ crasso. Ascis cylindricis in apice rostriformibus octosporis 95-135 x 11-13 μ. Paraphysibus filiformibus 1.5 μ latis et 95 μ longis. Ascosporis filiformibus 80-120 x 2-3 μ, gelatinoso involucro circiter 2 μ crasso. Pycnidiis numerosis nigris subcircularibus 50x80 ad 350x400 μ, in transversali sectione subcuticularibus, applanatis 30-40 μ profundis; conidiophoris 5-9 μ longis et 2-4 μ crassis, sitis in basilari plectenchymatis strato 7-12 μ crasso. Conidiis cylindricis bacillaribus 6.5-10.0 x 0.8-1.5 μ.

In foliis *Pini Strobi* L., Timagami, Ontario, mense Maio, 1924, Herbarium J. H. Faull, 4882, J. H. Faull legit.

Hysterothecia definite in outline, elliptical, mostly on the outer surfaces of the needles, shining black, opening by a narrow, sharply defined fissure, 0.60-0.85 x 0.35-0.49 mm., maturing on dead fallen needles, rarely on tips of partially green attached needles; hysterothecia in cross sectional view subcuticular, 0.15-0.25 mm. deep; basal plectenchyma 23-30 μ thick; covering layer of dark pseudoparenchyma and cuticle about 15-20 μ thick in lip region but considerably thicker laterally (27-37 μ); hymenium 110-120 μ thick. Asci cylindrical, rostriform at apex, 8-spored, 95-135 x 11-13 μ. Paraphyses uniform, slightly recurved and thickened at the tips, 1.5 μ wide, 95 μ long. Ascospores filiform, 80-120 x 2-3 μ, gelatinous envelope about 2 μ thick. Pycnidia numerous, black, wrinkled or smooth in appearance, subcircular, 50x80 to 350 x 400 μ, in cross section subcuticular, applanate, 30-40 μ deep; conidiophores 5-9 μ long, 2-4 μ thick, somewhat bacillar in shape, seated upon a basal layer of plectenchyma 7-12 μ thick. Conidia cylindrical, bacillar, 6.5-10.0 x 0.8-1.5 μ.

On Abietineae. *Pinus albicaulis* Engelm., California, Idaho, Oregon.—*Pinus Lambertiana* Dougl., California, Oregon.—*Pinus monticola* Dougl. ex Lamb., California, Idaho, Oregon, Washington.—*Pinus Strobus* L.: Massachusetts, Michigan, New Hampshire, Pennsylania, Washington; Nova Scotia, Ontario.

TYPE LOCALITY: Timagami, Ontario on *P. Strobus*, May, 1924, Herbarium J. H. Faull, 4882.

DISTRIBUTION: Northeastern North America and in the Pacific Northwestern United States.

EXSICCATI: Bartholomew, Fungi Columb. 4426; Seymour & Earle, Econ. Fung. 200.

OTHER SPECIMENS EXAMINED. Arnold Arboretum, Pathological Herbarium, coll. G. D. Darker. On *Pinus albicaulis*: 90, Priest River Forest Expt. Station, Idaho; 719, Lower Echo Lake, Eldorado Co., Cal.; 808, South slope, Mt. Hood, Oregon; 415, Crater Lake, Ore.—On *Pinus Lambertiana*, 511, Oregon Caves, Ore.—On *Pinus monticola*: 89, Priest River Forest Expt. Station, Idaho; 751, Government Camp, Ore.; 223, 306, Rhododendron, Ore.

Herbarium J. S. Boyce. On *P. albicaulis*: 1075, Crater Lake, Ore.; 1145, Cloud Cap Inn, Hood River Co., Ore.—On *P. Lambertiana*: 329, Massack, Cal.; 330, Sloat, Cal.; 827, Kirk, Ore.—On *P. monticola*: East Fork Trinity River, Trinity Co., Cal.; 17, Addie, Idaho, coll. E. E. Hubert; 1736, Government Camp, Ore., coll. L. N. Goodding & R. L. Macleod; 545, Gales City, Ore., coll. C. Eppling; 1053, Suiattle River, Skagit Co., Wash.—On *Pinus Strobus*: 344, Silverton, Wash.

Herbarium K. S. Chester. On *P. Strobus*: 316, New Ipswich, N. H.; 506, 525 (in part), Lake Winnepesaukee, N. H.

Herbarium J. Ehrlich. On *P. Strobus*: 712, Lake Le Merchant, Digby Co., N. S.

Herbarium J. H. Faull. On *P. Strobus*: 4882 (Type), Timagami Station, Ontario; 5096, 5587, 6529, 6549, 6554, Lake Timagami, Ont.

Herbarium University of Michigan, Department of Botany. On *P. Strobus*: Isle Royale, Michigan, coll. A. Povah.

Herbarium G. D. Darker. On *P. Strobus*: 3605, Monmouth, Me., coll. T. T. Ayers; 3504, Weirs, N. H.; 2010, Etobicoke Creek, Peel Co., Ont.; 1923, Blue Springs, Wellington Co., Ont.; 1067, 2017, Bond Lake, Ont.; 2037, Honey Harbour, Ont.; 1106, 1173, 1250, 1270, 1320, 1384, 1762, 1955, 2129, Lake Timagami, Ont.; 1063, 1267, 1635, 2003, 2004, 2020, Streetsville, Ont.; 2016, West Hill, York Co., Ont.

Lophodermium nitens is distinguished most readily from *Lophodermium pinastri* by the fact that the hysterothecial slit is not bounded by colorless, papillate cells. The hysterothecium of *L. nitens* opens by a tearing of the dark, carbonaceous, covering tissue which is very thin along the line of dehiscence. Another important diagnostic character is the position of the fruiting body in the host tissue. In *L. nitens* it is strictly subcuticular, while in *L. pinastri* it is subepidermal.

The time of infection has never been definitely established for *Lophodermium nitens*. It is known, however, that when needles of the current season are gathered and overwintered no hysterothecia develop during the following spring. Needles collected at the end of the second and third growing season produce hysterothecia when overwintered.

37. **Lophodermium uncinatum,** sp. nov.

Hysterotheciis praecipue epiphyllis conspersis interdum confluentibus 0.50-2.25 x 0.21-0.49 mm., ellipticis usque rectangularibus nitentibus atrofuscis; hysterotheciis in transversali sectione subcuticularibus 0.19-0.28 mm. profundis; basilari plectenchymate 18-30 μ crasso; tegente atri pseudoparenchymatis cuticulaeque strato 45-63 μ crasso; hymenio 150-160 μ crasso. Ascis cylindricis usque clavatis octosporis 105-135 x 13-15 μ. Paraphysibus aequabiliter filiformibus 135-160 μ longis et 1.0-1.5 μ crassis, maturitate in apicibus uncinatis. Ascosporis fasciculatis filiformibus 50-75 x 1.5-2.0 μ, muco 3-4 μ crasso involutis. Pycnidiis parvis rotundatis vel ellipticis flavidis usque aurantiacis maturitateque nigricantibus maximopere numerosis conspicuisque subcuticularibus 110-210 x 160-325 μ. Conidiis bacillaribus hyalinis 4-6 x 0.8-1.0 μ.

In foliis *Abietis amabilis* (Dougl.) Forb., Government Camp, Oregon, mense Iulio, 1929, Arnold Arboretum, Pathological Herbarium, 275, G. D. Darker legit.

Hysterothecia chiefly epiphyllous, scattered, occasionally confluent, 0.50-2.25 x 0.21-0.49 mm., elliptical to rectangular in shape, shining, brownish black; hysterothecia in cross section subcuticular, 0.19-0.28 mm. deep; basal plectenchyma 18-30 μ thick, extending laterally up the sides of the hysterothecium; covering layer of dark pseudoparenchyma and cuticle 45-63 μ thick; hymenium 150-160 μ thick. Asci cylindric to clavate, somewhat rostriform at tip, 8-spored, 105-135 x 13-15 μ. Paraphyses uniformly filiform, up to 135-160 μ long, about 1.0-1.5 μ thick, at maturity strongly uncinate at tips. Ascospores fasciculate, filiform, 50-75 x 1.5-2.0 μ, with a gelatinous sheath 3-4 μ thick. Pycnidia form small, rounded or elliptical blisters, yellowish to reddish orange becoming black at maturity, extremely numerous and conspicu-

ous, subcuticular, 160-325 x 110-210 μ. Conidia bacillar, hyaline, 4-6 x 0.8-1.0 μ.

On Abietineae: *Abies amabilis* (Dougl.) Forb., Oregon.

Type Locality: Government Camp, Clackamas County, Oregon, on *A. amabilis,* July, 1929. Arnold Arboretum, Pathological Herbarium, 275, coll. G. D. Darker.

Distribution: Known only from the region near the type locality.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Abies amabilis*: 209, Barlow Creek Road, near Mt. Hood, Ore., coll. L. N. Goodding & G. D. Darker; 275, Government Camp, Ore., coll. G. D. Darker.

Lophodermium uncinatum appears to be a weak parasite occurring mostly on heavily shaded branches. In certain features the hysterothecia resemble those of *Lophodermium autumnale* but the numerous, small, colored pycnidia at once distinguish *L. uncinatum* from *L. autumnale* in the field.

38. **Lophodermium autumnale,** sp. nov.

Hysterotheciis amphigenis in foliis initio a fungo nervisequi habitus ex familia Hypodermatacearum infectis ellipticis atronitidis 0.40-0.80 x 0.27-0.42 mm.; hysterotheciis in transversali sectione subcuticularibus 0.16-0.29 mm. profundis; basilari plectenchymate 15-23 μ crasso; tegente pseudoparenchymatis strato 45-50 μ crasso; hymenio 105-150 μ crasso. Ascis clavatis octosporis 110-160 x 12-15 μ. Paraphysibus aequabiliter filiformibus 1 μ crassis circiter 150 μ longis. Ascosporis filiformibus 85-95 x 1.5-2.0 μ, muco 3-5 μ crasso involutis.

In foliis *Abietis balsameae* (L.) Mill., Claude Lake, Gaspé County, Quebec, mense Septembri, 1928, Herbarium J. H. Faull, 8748, J. H. Faull legit.

Hysterothecia amphigenous, scattered or crowded and frequently confluent, occurring on needles primarily attacked by one of the Hypodermataceous fungi of the "nervisequious" habit, elliptical, shining black, 0.40-0.80 x 0.27-0.42 mm.; hysterothecia in cross section subcuticular, 0.16-0.29 mm. deep; basal plectenchyma 15-23 μ thick; covering layer pseudoparenchymatous, 45-50 μ thick; hymenium 105-150 μ thick. Asci clavate, 8-spored, 110-160 x 12-15 μ. Paraphyses uniformly filiform, at maturity recurved at tips, 1 μ thick, about

150 μ long. Ascospores filiform, 85-95 x 1.5-2.0 μ, gelatinous sheath 3-5 μ thick.

On Abietineae. *Abies amabilis* (Dougl.) Forb., Oregon.—*Abies balsamea* (L.) Mill.: Michigan; Nova Scotia, Ontario, Quebec.—*Abies concolor* Lindl. & Gord., Oregon.—*Abies lasiocarpa* (Hook.) Nutt.; Idaho; Wyoming.—*Abies nobilis* Lindl., Oregon.

Type Locality: Claude Lake, Gaspé County, Quebec on *A. balsamea*. Herbarium J. H. Faull, 8748, Sept. 1928, coll. J. H. Faull.

Distribution: Eastern Canada and northwestern United States.

Specimens Examined. Arnold Arboretum, Pathological Herbarium, coll. G. D. Darker. On *Abies amabilis*: 152 (in part), 161, Government Camp, Ore.; 340, near Shellrock Lake, Clackamas County, Ore.—On *Abies concolor*: 515 (in part), 524, 549, 556, Oregon Caves, Ore.—On *Abies lasiocarpa*: 88, Priest River Forest Experiment Station, Idaho.—On *Abies nobilis*: 210, Barlow Creek Road, Mt. Hood, Ore.

Herbarium J. H. Faull. On *Abies balsamea*: 9275 (in part), Liscomb Park, Guysboro County, N. S.; 5597 (in part), Lake Timagami, Ontario; 6689, Shipshaw Mts., along Shipshaw River, Quebec; 8712 (in part), McNab Mt., Shickshock Mts., Gaspé County, Quebec; 8684 (in part), 8748, 8773 (in part), 9071 (in part), Claude Lake, Gaspé County, Quebec.

Herbarium University of Michigan, Department of Botany. On *A. balsamea*: Raspberry Island, near Isle Royale, Michigan, coll. A. Povah.

Herbarium G. D. Darker. On *A. balsamea*: 1330, 1362, 1391, 1432, 1528, 1622, 1657, 1897, 2172, 2424, Lake Timagami, Ontario.

Lophodermium autumnale has the very interesting habit of following secondarily after certain other Hypodermataceous species. It is commonly found on needles primarily attacked by *Bifusella Faullii* in eastern America and by *Hypoderma robustum* in western America. It is sometimes present in such abundance that it serves to act as a check on the spread of the "nervisequious" species.

39. **Lophodermium Thuyae** Davis in Trans. Wisc. Acad. Sci. Arts & Lett. **20**:424 (1922).

Hysterothecia on dead, attached or fallen needles, elliptical, shining black, amphigenous, 0.60-0.90 x 0.25-0.40 mm.; lips prominent; hysterothecia in cross section 0.18-0.25 mm. deep, subcuticular; basal layer of dark pseudoparenchyma merging into a light colored plectenchyma above, 23-30 μ thick; covering layer of outer epidermal wall and dark pseudoparenchyma 30-45 μ thick; hymenium 115-135 μ thick. Asci almost cylin-

drical, 4-spored, 100-125 x 9-11 μ. Paraphyses uniform, at maturity clavate and sending out sinuate growths from the tips, 2 μ wide, 115 μ long. Ascospores filiform, 85-115 x 1.5-2 μ, surrounded by a thin gelatinous sheath 1-2 μ in thickness.

On Cupressineae: *Thuja occidentalis* L., New Hampshire, Wisconsin; Ontario.

Type Locality: Saxon, Wisconsin on *T. occidentalis*.

Distribution: Northern New Hampshire, Northern Ontario to Wisconsin.

Illustrations: Trans. Wisc. Acad. Sci., Arts and Letters 20:425, fig. 2 A, B, C. 1922.

Exsiccati: Davis, Fungi Wisc. 114.

Other Specimens Examined. Herbarium W. G. Farlow. On *Thuja occidentalis*: Alpine Cascade, Gorham, N. H.

Herbarium J. H. Faull. On *T. occidentalis*: 7508, Saxon, Wisc., coll. J. J. Davis; 5093, 6522, 6605, Lake Timagami, Ontario.

Herbarium G. D. Darker. On *T. occidentalis*: 1128, Ingall Lake, Timagami Forest Reserve, Ontario; 1134, Kettle Lake, Timagami Forest Reserve, Ont.; 1075, 1169, 1186, 1247, 1257, 1305, 1326, 1353, 1514, 1515, 1538, 1590, 2099, 2416, Lake Timagami, Ont.

Comparison of Ontario material with type material from Dr. J. J. Davis leaves no doubt as to the identity of the Ontario material. Certain features of the original illustrations are rather weak. *Lophodermium Thuyae* is subcuticular and not subepidermal as illustrated. Furthermore, the spores are four in number in each ascus at maturity.

Lophodermium Thuyae is chiefly of interest taxonomically; it has no economic importance.

40. **Lophodermium consociatum**, sp. nov.

Hysterotheciis schistaceis subcircularibus usque ellipticis praecipue hypophyllis 0.4-0.6 x 0.6-1.7 mm., in foliis initio ab Hypodermate robusto v. Tub. infectis, intraepidermalibus longitrorsum aperientibus; hysterothecio in transversali sectione 225-315 μ profundo, cum tegente atri pseudoparenchymatis strato 75-130 μ crasso, basilari parenchymatis strato 16-20 μ crasso; hymenio 150-180 μ crasso. Ascis angustis clavatisque 160-180 x 15-18 μ octosporis. Paraphysibus simplicibus filiformibus 1 μ crassis 150 μ longis. Ascosporis filiformibus parum clavatis 95-120 x 2.0-2.5 μ hyalinis, muco 2-3 μ crasso involutis.

In foliis *Abietis amabilis* (Dougl.) Forb., Government

Camp, Oregon, mense Iulio, 1929, Arnold Arboretum, Pathological Herbarium, 268, G. D. Darker legit.

Hysterothecia grayish black, subcircular to elliptical in outline, chiefly hypophyllous, 0.4-0.6 x 0.6-1.7 mm., on needles first attacked by *Hypoderma robustum* v. Tubeuf, intraepidermal, opening by a longitudinal slit; hysterothecia in cross section 225-315 μ deep, with a dark pseudoparenchymatous covering layer 75-130 μ thick, tapering out uniformly toward the margin; basal layer plectenchymatous, 16-20 μ thick, extending laterally in a very thin layer; hymenium 150-180 μ thick. Asci narrowly clavate, 150-180 x 15-18 μ, 8-spored, rounded at the tips. Ascospores filiform, somewhat clavate, 95-120 x 2.0-2.5 μ, hyaline, surrounded by a gelatinous sheath 2-3 μ thick. Paraphyses simple, filiform, about 1 μ thick, up to 150 μ long.

On Abietineae: *Abies amabilis* (Dougl.) Forb., Oregon.

Type Locality: Government Camp, Ore., on *A. amabilis,* July, 1929, Arnold Arboretum, Pathological Herbarium, 268, coll. G. D. Darker.

Distribution: Known only from the district immediately south of Mt. Hood, Ore.

Specimens Examined. Arnold Arboretum, Pathological Herbarium, coll. G. D. Darker. On *Abies amabilis*: 268 (Type), Government Camp, Ore.; 338, near Shellrock Lake, Clackamas County, Ore.

Lophodermium consociatum follows up as a secondary organism on needles primarly attacked by a species of the "nervisequious" type. It resembles *Lophodermium autumnale* in this habit but differs from it by the fact that the hysterothecia of *L. autumnale* are subcuticular. *Lophodermium decorum* which it resembles even more closely in general appearance is a subepidermal species.

41. **Lophodermium lacerum,** sp. nov.

Hysterotheciis hypophyllis in duobus ordinibus, brevibus ellipticis obscure usque nitide atris, 0.50-0.75 x 0.28-0.39 mm., longitudinali incisura in plures lobos lacerata late aperientibus; labiis conspicuis atris; hysterotheciis in transversali sectione intraepidermalibus 0.15-0.25 mm. profundis; hypothecio basilaris atri pseudoparenchymatis strati plectenchymatisque candidi 10-27 μ crasso; tegente exterioris epidermalisque parie-

tis pseudoparenchymatisque colorati strato 45-60 μ crasso; hymenio 115-125 μ crasso. Ascis clavatis subfusiformibus octosporis 100-125 x 12.5-16.0 μ. Paraphysibus 1 μ crassis usque 115 μ longis. Ascosporis clavatis basi abrupte attenuatis 60-80 x 1.5-2.5 μ hyalinis, muco 3-4 μ crasso involutis. Pycnidiis intraepidermalibus nigris 120-170 x 100-120 μ. Conidiis hyalinis bacillaribus 3-5 x 1.0-1.5 μ.

In foliis *Abietis balsameae* (L.) Mill., Lake Timagami, Ontario, mense Iunio, 1925, Arnold Arboretum, Pathological Herbarium, 820, G. D. Darker legit.

Hysterothecia hypophyllous, in a row along each side of the needle, short, elliptical, dull to shining black, 0.50-0.75 x 0.28-0.39 mm., opening widely by a longitudinal slit which becomes torn laterally into several lobes; lips prominent, dark; hysterothecia in cross section intraepidermal, 0.15-0.25 mm. deep; hypothecium of dark pseudoparenchymatous basal layer and light colored plectenchyma, 10-27 μ thick; covering layer of outer epidermal wall and colored pseudoparenchyma 45-60 μ thick; hymenium 115-125 μ thick. Asci clavate, somewhat fusiform, 8-spored, 100-125 x 12.5-16.0 μ. Paraphyses about 1 μ thick, swollen at the tips, up to 115 μ long. Ascospores clavate, becoming abruptly acute at the base, 60-80 x 1.5-2.5 μ, hyaline, with a gelatinous sheath 3-4 μ in thickness. Pycnidia intraepidermal, black, 120-170 x 100-120 μ. Conidia hyaline, bacillar, 3-5 x 1.0-1.5 μ.

On Abietineae. *Abies balsamea* (L.) Mill.: New Hampshire, New York, Pennsylvania, Vermont; Ontario, Quebec.

Type Locality: Lake Timagami, Ontario, on *A. balsamea,* June, 1925. Arnold Arboretum, Pathological Herbarium, 820, coll. G. D. Darker.

Distribution: Eastern Canada and northeastern United States.

Specimens Examined: Arnold Arboretum, Pathological Herbarium. On *Abies balsamea*: 820, Lake Timagami, Ontario, coll. G. D. Darker.

Herbarium J. S. Boyce. On *A. balsamea*: 1479, Chesterton, N. Y.; 1395, Bear Meadows, Penna., coll. C. R. Orton.

Herbarium Office of Forest Pathology, U. S. Department of Agriculture. On *A. balsamea*: 16205, Carroll, N. H., coll. P. Spaulding; 2503, Bethel, Vt., coll. P. Spaulding.

Herbarium J. H. Faull. On *A. balsamea*: 5099, 6528, 6535, 6539, 7356, Lake Timagami, Ontario; 8811, 8833, Ste. Anne des Monts, Quebec.

Herbarium G. D. Darker. On *A. balsamea*: 1081, 1168 (in part), 1243, 1255, 1273, 1292, 1297, 1398, 1664, 1763, 2143, Lake Timagami, Ontario; 2202, Lake Timagami, Ontario, coll. J. H. Faull.

Lophodermium lacerum is mainly of mycological interest. It is found abundantly on the lower shaded branches of *Abies balsamea*.

42. **Lophodermium Piceae** (Fuckel) von Höhnel in Sitzb. Akad. Wissensch. Wien Math.-Naturw. Kl. **126**(1):296 (1917).

Phacidium Piceae Fuckel, Symb. Myc. Zweiter Nachtrag, 51 (1873).

Coccomyces Piceae Saccardo, Syll. Fung. **8**:746 (1889).

Lophodermium Abietis Rostrup in Tidskr. Skovbr. **12**:201 (1891).

Lophodermellina pinastri von Höhnel in Ann. Myc. **15**:311 (1917), quoad descriptionem.

Hypodermina Abietis Hilitzer in Vědecké Spisy Vyd. Československ. Akad. Zeměd. **3**:60 (1929).

Hysterothecia scattered, elliptical, shining black, amphigenous, 0.60-1.90 x 0.40-0.77 mm., opening by a longitudinal slit but separating widely by lateral fissures at maturity; lips conspicuous, black; hysterothecia in cross sectional view intraepidermal, 0.28-0.42 mm. deep, basal layer plectenchymatous, 15-25 μ thick; covering layer of epidermal wall and dark brown pseudoparenchyma 75-100 μ thick at centre, tapering gradually towards the margins; hymenium 120-140 μ thick; disc flat. Asci subcylindrical, apex acute, 8-spored, 110-130 x 10-12 μ. Paraphyses filiform, 1 μ in width, 125 μ in length, swollen terminally and at maturity occasionally branching. Ascospores filiform, 60-95 x 1.5-2.0 μ, with sheath about 2 μ thick. Pycnidia intraepidermal, dark colored, 200-400 x 130-180 μ. Conidia bacillar, 3.0-4.5 x 0.8-1.0 μ.

On Abietineae. *Abies alba* Mill., Denmark.—*Abies balsamea* (L.) Mill., Ontario.—*Abies concolor* Lindl. & Gord., Oregon.—*Abies lasiocarpa* (Hook.) Nutt., Oregon.—*Picea Abies* (L.) Karst.: Massachusetts; Ontario; Denmark; Germany.—*Picea glauca* (Moench) Voss: Michigan; Ontario, Quebec; Denmark.—*Picea Engelmannii* (Parry) Engel., Oregon.—*Picea mariana* (Mill.) BSP., Ontario, Quebec.—*Picea rubra* (DuRoi) Dietr., New York.—*Picea sitchensis* Carr.: California, Oregon; Denmark; Scotland.

TYPE LOCALITY: Frankensteiner Kopf, Bavaria, Germany on *Picea Abies*.

DISTRIBUTION: Central Europe, eastern and western North America.

ILLUSTRATIONS: Tidskr. Skovbr. **12**:201, fig. 3 a, b, c; 203, fig. 4 b. 1891.

EXSICCATI: Fuckel, Fungi rhen. 2561.

OTHER SPECIMENS EXAMINED. Arnold Arboretum, Pathological Herbarium, coll. G. D. Darker. On *Abies concolor*: 608, Oregon Caves, Ore.—On *Abies lasiocarpa*: 273, Government Camp, Ore.—On *Picea Engelmannii*: 211, near Mt. Hood, Ore.—On *Picea sitchensis*: 637, Requa, California.

Herbarium J. S. Boyce. On *P. sitchensis*: 1151, Hebo, Ore.; 1533, Glentress, Scotland.

Herbarium J. Ehrlich. On *Picea rubra*: 91, Woodgate, N. Y.

Herbarium J. H. Faull. On *Abies balsamea*: 9322 (in part), Lake Timagami, Ontario.—On *Picea glauca*: 8838, Ste. Anne des Monts, Quebec; 8808, 8834, 9078, Claude, Quebec; 8040, St. Élie, Quebec. —On *Picea mariana*: 8721 (in part), Shickshock Mts., Gaspé County, Quebec.

Herbarium University of Michigan, Department of Botany. On *P. glauca*: Isle Royale, Michigan, coll. A. Povah.

Herbarium G. D. Darker. On *Abies balsamea*: 1920, near Blue Springs, Wellington County, Ontario; 1168, 1242, 1254, 1281, 1293, 1321, 1951, 2141, Lake Timagami, Ontario.—On *Picea Abies*: 2483, Arnold Arboretum, Jamaica Plain, Massachusetts; 2488, West Newberry, Mass.; 2025, Eldorado Park, Peel County, Ontario; 1061, 1062, 1266, 2021, Streetsville, Ontario.—On *P. glauca,* 1921, Blue Springs, Wellington County, Ontario; 2026, 2030, Eldorado Park, Peel County, Ontario; 1088, 1100, 1235, 1271, 1279, 1280, 1298, 1465, 1671, Lake Timagami, Ontario.—On *P. mariana,* 1066, 2018, Bond Lake, York County, Ontario; 1170, 1282, 1299, 1328, 1455, Lake Timagami, Ontario.

The needle cast caused by *Lophodermium Piceae* was considered by Rostrup to rank next to *Trametes radiciperda* in importance as a disease of Spruce in Denmark. In America, however, it is not a serious disease and it occurs only on old needles which are about to drop from natural causes or on densely shaded needles in moist situations. Although probably a weak parasite, parasitism has never been demonstrated. *L. Piceae* is found on a wide range of hosts and is one of two species of Hypodermataceae known to occur on host species belonging to more than a single host genus.

Von Höhnel (1917[2, 4]) regarded *Lophodermium Piceae* as synonymous with *Lophodermium pinastri* and did not recog-

nize it as a distinct species. The writer has examined the material under the label *Lophodermellina pinastri* in v. Höhnel's herbarium but has been unable to find a specimen of *Lophodermium pinastri* present in it. His description of *Lophodermellina pinastri* has been based upon *L. Piceae* and therefore *Lophodermellina pinastri* must be regarded, at least partly, as a synonym of *L. Piceae*.

Boyce (1928) pointed out that *Pseudotsuga* reported along with *Picea Abies* by Lind (1913) as a host of *Lophodermium Piceae* was based upon an error in host determination, Pseudotsuga needles being mixed among infected spruce needles in the same herbarium packets.

In America *Lophodermium Piceae* has been used indiscriminately as a name for several species. At least *Lophodermium autumnale, Lophodermium lacerum, Lophodermium uncinatum* and *Lophodermium filiforme* should be looked for under the label of *L. Piceae* in most herbaria. It is distinguished from *Lophodermium filiforme* and *L. macrosporum* by its narrowly cylindrical asci and by its short elliptical hysterothecia, and from *Lophodermium crassum, L. autumnale* and *L. uncinatum* by its intraepidermal hysterothecia. The large flat pycnidia of *L. Piceae* separate it at once from all other species on *Abies* and *Picea* except *L. macrosporum* and *L. crassum*. *L. macrosporum,* however, has linear ascocarps while *L. crassum,* a more closely related species, is subepidermal in position.

43. **Lophodermium macrosporum** (Hartig) Rehm in Rabenhorst's Kryptogamen-Flora, **1**(3):45 (1887).

Hysterium macrosporum Hartig, Wicht. Krankh. Waldb. 101 (1874).

Hypodermella macrospora Lagerberg in Medd. Stat. Skogsförsöksanst. **7**:113 (1910).

Hypodermina Hartigii Hilitzer in Vědecké Spisy Vyd. Československ. Akad. Zeměd. **3**:57 (1929).

Hysterothecia hypophyllous, variable in length, sometimes extending the full length of the needle, 0.45-0.56 mm. wide, shining black; lips conspicuous; disc pale yellow; hysterothecia in cross section almost circular in outline before opening, hymenium flat when open, intraepidermal, 0.21-0.30 mm. deep; basal layer of plectenchyma 25-30 μ thick; covering

layer of dark pseudoparenchyma and outer epidermal wall 55-68 μ thick; hymenium 105-120 μ thick. Asci clavate cylindric, tapering abruptly at tip, 100-132 x 14-16 μ, 8-spored. Paraphyses simple, filiform, up to 120 μ long, 1.5-2.0 μ thick, swollen at tips. Ascospores clavate, hyaline, 56-68 x 2.5-3.0 μ, surrounded by a gelatinous sheath 3-4 μ thick. Pycnidia concolorous with leaf surface, conspicuous, applanate.

On Abietineae. *Picea Abies* (L.) Karst.: Czechoslovakia; Denmark; France; Germany; Norway; Poland; Sweden; Switzerland.

Type Locality: Treves, Germany, on *P. Abies*.

Distribution: Scandinavian Peninsula to Central Europe.

Illustrations: Hartig, Wicht. Krankh. Waldb. pl. 6, fig. 1-17. 1874.

Exsiccati: Krieger, Fungi sax. 777; Petrak, Fl. Boh. & Mor. Exs. II Ser. 2052; Rabenhorst, Fungi Europ. 2411; Siemaszko, Fungi Bialow. Exs. 16; De Thümen, Myc. Univ. 279.

Other Specimens Examined. Herbarium J. S. Boyce. On *Picea Abies*: 1518, Fyn, Skaarup, Denmark, coll. E. Rostrup; 1631, Almindingen, Bornholm, Denmark; 1464, Lu Ditz, Czechoslovakia.

Herbarium J. H. Faull. On *P. Abies,* 7150, Central Europe, coll. P. Vogel.

Herbarium G. D. Darker. On *P. Abies*: 3328, Hyggen, Norway, coll. Ivar Jørstad; 3329, near Oslo, Norway, coll. Ivar Jørstad; 3330, Sørfjellet, Norway, J. G. Juul.

Lophodermium macrosporum has been known for many years in Europe. Hartig (1874) was the first, however, to point out the fact that it was distinct from *Hypodermella nervisequia* on *Abies*. His research on the morphology and development of *L. macrosporum* has become a classic among investigations dealing with the Hypodermataceae.

Lophodermium macrosporum is a parasitic form widely distributed in Europe. It is a very close ally of *Lophodermium filiforme* of America but its spores are only 50-75 μ in length whereas those of *L. filiforme* attain commonly a length of 135-160 μ.

44. **Lophodermium filiforme,** sp. nov.

Hysterotheciis praecipue hypophyllis brevibus usque elongatis linearibusque atronitidis 0.25-0.56 mm. latis; disco stramineo colore; hysterotheciis in transversali sectione intraepidermalibus 0.25-0.28 mm. profundis; basilari plectenchymatis strato 24-30 μ crasso; tegente atri pseudoparenchymatis pari-

etisque epidermalis strato 60-80 μ crasso; hymenio 135-160 μ crasso. Ascis cylindricis 135-160 x 16-17 μ typice octosporis interdum tantum quattuor sporis maturantibus raroque tantum una aut duabus. Paraphysibus filiformibus paene tam longis quam ascis. Ascosporis fasciculatis filiformibus 115-160 x 2.5-3.0 μ, muco circiter 3 μ crasso involutis. Pycnidiis minutis cereis applanatis obscuris. Conidiis bacillaribus usque allantoideis 5.0-9.5 x 0.8-1.2 μ.

In foliis *Piceae glaucae* (Moench) Voss, Lake Timagami, Ontario, mense Iulio, 1926, Arnold Arboretum, Pathological Herbarium, 822, G. D. Darker legit.

Hysterothecia chiefly hypophyllous, short to elongated linear, often extending the whole length of the needle, shining black, 0.25-0.56 mm. wide; disc straw yellow in color; hysterothecia in cross section intraepidermal, 0.25-0.28 mm. deep; basal layer plectenchymatous, 24-30 μ thick; covering layer of dark pseudoparenchyma and epidermal wall 60-80 μ thick; hymenium 135-160 μ thick. Asci cylindric, abruptly pointed at apex, 135-160 x 16-17 μ, usually 8-spored, occasionally with only 4 mature spores and rarely only 1 or 2. Paraphyses filiform, about the same length as the asci, slightly swollen at tips. Ascospores fasciculate, filiform, 115-160 x 2.5-3.0 μ, enclosed within a gelatinous sheath about 3 μ in thickness. Pycnidia minute, applanate, waxy, inconspicuous, more or less concolorous with leaf surface. Conidia bacillar to allantoid, 5.0-9.5 x 0.8-1.2 μ.

On Abietineae. *Picea glauca* (Moench) Voss, Ontario, Quebec.—*Picea Engelmannii* (Parry) Engelm., Colorado.—*Picea mariana* (Mill.) BSP., Ontario.

Type Locality: Lake Timagami, Ontario on *P. glauca,* July, 1926, Arnold Arboretum, Pathological Herbarium, 822, coll. G. D. Darker.

Distribution: Eastern Canada and in Central Rocky Mountains.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Picea glauca*: 822 (Type), Lake Timagami, Ontario, coll. G. D. Darker.

Herbarium J. H. Faull. On *P. glauca*: 8806, Claude, Quebec; 8841, Ste. Anne des Monts, Quebec; 8039, St. Élie, Quebec.

Herbarium G. D. Darker. On *P. glauca*: 3398, Fredericton, N. B., coll. J. M. Swaine; 1548, 1627, 1638, 1680, 1803, 2051, 2070, 2328, 2342, Lake Timagami, Ontario.—On *Picea mariana*: 1575, Lake Timagami, Ontario.

The nearest ally of *Lophodermium filiforme* is *Lophodermium macrosporum* of Europe from which it differs chiefly in the shape of the asci and spores which are more typically Lophodermium-like in character in *L. filiforme*. The ascospores of the American species are two to three times as long as those of the European species.

Lophodermium filiforme is known only from very localized areas. Where established, however, it is very destructive and in middle-aged stands the lower parts of the crowns may become almost completely defoliated. In eastern America *Naevia piniperda* Rehm has always been found in association with *Lophodermium filiforme,* just as Lagerberg (1928) has reported it along with *Lophodermium macrosporum* in Sweden. *N. piniperda* establishes itself on needles attacked primarily by the Lophodermium which it prevents from reaching maturity. As a result of this interesting association there is indication that periods of heavy infection by the Lophodermium species alternate in cycles with periods of infection of considerably less intensity.

All needles infected with *Lophodermium filiforme* are fairly uniform in color at a given stage in the development of the disease. In dried material collected in early June in northern Ontario, leaves with hysterothecia present were pale yellow orange (Ridgway, 1912) and leaves with pycnidia were light ochraceous salmon (R) color. The discs of fresh hysterothecia appeared light ochraceous buff (R).

45. **Lophodermium durilabrum,** sp. nov.

Hysterotheciis atrofuscis conspicuis 0.38-0.53 x 0.88-1.75 mm.; hysterotheciis in transversalis sectionis aspectu subhypodermalibus in centro, marginem versus subepidermalibus 195-230 μ profundis; basilari plectenchymate 30-33 μ crasso; tegente strato epidermide et hypodermide superimpositis inclusis 60-75 μ crasso; hymenio 115-125 μ crasso. Ascis cylindricis 110-128 x 8-9 μ octosporis. Paraphysibus filiformibus 115-130 μ longis et 1 μ crassis, conspicuo muco involutis. Ascosporis fasciculatis filiformibus 90-105 x 0.8-1.0 μ muco 1-2 μ crasso involutis.

In foliis *Pini monticolae* Douglas, Horsethief Meadows, Hood River County, Oregon, mense Iulio, 1929, Arnold Ar-

boretum, Pathological Herbarium, 157, L. N. Goodding et G. D. Darker legerunt.

Hysterothecia on outer, abaxial surfaces of reddish-brown attached needles, 0.38-0.53 x 0.88-1.75 mm., brownish-black, subepidermal at edges, in central portion subhypodermal; hysterothecia in cross sectional view 195-230 μ deep; basal plectenchyma 30-33 μ thick, extending laterally up the sides of the hysterothecia; covering layer (including the overarched epidermis and hypodermis) 60-75 μ thick, innermost dark pseudoparenchyma cells, especially in the central portion, arranged in vertical rows, pseudoparenchyma of fairly uniform thickness over whole hysterothecium except in thickened central region; hymenium 115-125 μ thick. Asci cylindrical, 110-128 x 8-9 μ, tapering abruptly and acutely at the tip, 8-spored. Ascospores fasciculate, filiform, 90-105 x 0.8-1.0 μ, with a gelatinous sheath 1-2 μ in thickness. Paraphyses filiform, about 115-130 μ long and 1 μ in thickness, surrounded by a conspicuous gelatinous sheath.

On Abietineae: *Pinus monticola* Douglas, Oregon.

Type Locality: Horsethief Meadows, Hood River County, Oregon on *P. monticola,* July, 1929, Arnold Arboretum, Pathological Herbarium, 157, coll. L. N. Goodding & G. D. Darker.

Distribution: known only from the type locality.

Specimen Examined. Arnold Arboretum, Pathological Herbarium. On *Pinus monticola*: 157, Horsethief Meadows, Hood River County, Oregon, coll. L. N. Goodding & G. D. Darker.

The hysterothecia of *Lophodermium durilabrum* are subhypodermal in the centre and are therefore readily distinguished from the other species which occur on *Pinus monticola*. *Lophodermium pinastri* is always subepidermal and *Lophodermium nitens* and *Bifusella linearis* are subcuticular.

Lophodermium durilabrum was found on browned needles of young trees and appeared to be weakly parasitic.

46. **Lophodermium crassum,** sp. nov.

Hysterotheciis conspersis amphigenis 0.55-0.74 mm. latis et 0.80-2.63 mm. longis atronitidis; hysterotheciis in transversali sectione subepidermalibus 0.32-0.50 mm. profundis; laxo basilarique plectenchymate 45-60 μ crasso; tegente atri pseudoparenchymatis epidermidisque strato 165-180 μ crasso; hymenio 150-165 μ crasso. Ascis cylindricis usque clavatis 145-

165 x 9-11 μ octosporis. Paraphysibus simplicibus linearibus 120-150 x 1.5-2.0 μ. Ascosporis filiformibus hyalinis 90-105 x 1.0-1.5 μ. Pycnidiis subepidermalibus 0.50-1.25 mm. longis et 0.32-0.49 mm. latis, in transversali sectione 100-175 μ profundis; basilari brunneoli pseudoparenchymatis hyalinique plectenchymatis strato 45-90 μ crasso; conidiophoris simplicibus 15-30 μ longis. Conidiis bacillaribus hyalinis 0.8-1.2 x 4-5 μ.

In foliis *Piceae Brewerianae* S. Wats., Young's Valley, Siskiyou Co., California, aestate, 1929, Arnold Arboretum, Pathological Herbarium, 797, John H. Maxson legit.

Hysterothecia scattered, amphigenous, 0.55-0.74 mm. wide, 0.80-2.63 mm. long, shining black; hysterothecia in cross sectional view subepidermal, 0.32-0.50 mm. deep; loose basal plectenchyma 45-60 μ thick; covering layer of dark pseudoparenchyma and epidermis 165-180 μ thick; hymenium 150-165 μ thick. Asci cylindric to clavate, 145-165 x 9-11 μ, 8-spored. Ascospores filiform, hyaline, 90-105 x 1.0-1.5 μ. Paraphyses simple, linear, 120-150 x 1.5-2.0 μ, surrounded by a delicate gelatinous sheath. Pycnidia subepidermal, 0.50-1.25 mm. long, 0.32-0.49 mm. wide, opening by a longitudinal slit along one or both lateral edges; in cross sectional view 100-175 μ deep; basal layer of brownish colored pseudoparenchyma and hyaline plectenchyma 45-90 μ thick; conidiophores simple, 15-30 μ long. Conidia bacillar, hyaline, 0.8-1.2 x 4-5 μ.

On Abietineae: *Picea Breweriana* S. Wats., California.

Type Locality: Young's Valley, Siskiyou County, California on *P. Breweriana,* Summer, 1929, Arnold Arboretum, Pathological Herbarium, 797, coll. John H. Maxson.

Distribution: known only from the type locality.

Specimen Examined. Arnold Arboretum, Pathological Herbarium. On *Picea Breweriana*: 797, Young's Valley, Siskiyou County, California, coll. John H. Maxson.

Lophodermium crassum is similar in many respects to *Lophodermium Piceae* but its hysterothecia are subepidermal and have an extremely thick clypeus. The asci and ascospores are also considerably larger than those of *L. Piceae.* Like *L. Piceae* it also causes a weak needle casting and the hysterothecia mature on the fallen needles.

47. **Lophodermium decorum**, sp. nov.

Hysterotheciis hypophyllis brevibus ellipticis schistaceis 0.30-0.56 x 0.50-1.13 mm. supepidermalibus; labiis obscuris; hysterotheciis in transversali sectione ad 250-300 μ profundis; basilari plectenchymate 15-30 μ crasso; tegente atri pseudoparenchymatis epidermidisque strato 65-90 μ crasso; hymenio plano 160-195 μ crasso. Ascis clavatis in apice rotundatis 140-184 x 16-18 μ. Paraphysibus filiformibus 1 μ crassis circiter 180 μ longis. Ascosporis clavatis 55-75 x 3-4 μ hyalinus, muco 4-5 μ crasso involutis.

In foliis *Abietis grandis* Lindl., Troy, Montana, mense Iulio, 1924, Herbarium J. S. Boyce, 1247a, J. S. Boyce legit.

Hysterothecia hypophyllous in two rows along the stomatal surfaces of the needles, short, elliptical, grayish-black, 0.30-0.56 x 0.50-1.13 mm., subepidermal, opening by a longitudinal slit; lips inconspicuous, dark; hysterothecia in cross section up to 250-300 μ deep (open); basal plectenchyma 15-30 μ thick with an irregular layer of dark cells extending below this into the host tissue; dark pseudoparenchymatous covering layer (including thickness of epidermis) 65-90 μ thick; hymenium flat, 160-195 μ thick. Asci clavate, rounded at tip, tapering gradually toward the base, 140-184 x 16-18 μ. Paraphyses about 1 μ in thickness, and about 180 μ in length, surrounded by a thin gelatinous envelope. Spores clavate, tapering rather abruptly toward the base, rounded at tip, 55-75 x 3-4 μ, hyaline, with a gelatinous sheath 4-5 μ in thickness.

On Abietineae: *Abies grandis* Lindl., Montana, Oregon.

Type Locality: Troy, Lincoln County, Montana, on *A. grandis*, July, 1924, Herbarium J. S. Boyce, 1247 a, coll. J. S. Boyce.

Distribution: known only from the type locality and neighborhood of Mt. Hood, Ore.

Specimens Examined. Arnold Arboretum, Pathological Herbarium. On *Abies grandis*: 185, Rhododendron, Ore., coll. G. D. Darker.

Herbarium J. S. Boyce. On *A. grandis*: 1247a (type), Troy, Montana.

Lophodermium decorum is closely related to *Lophodermium lacerum* of eastern North America. Its occurrence on heavily shaded branches suggests weak parasitism. It differs from *L. lacerum* in the larger size of its asci and spores and also

in the fact that the hysterothecia of *L. decorum* are subepidermal whereas those of *L. lacerum* are intraepidermal.

48. **Lophodermium Chamaecyparisii** Shirai & Hara in Bot. Mag. Tokyo, **25**:69 (1911).

Hysterothecia scattered, black, elevated, elliptical or circular, longitudinally dehiscent, 0.50-0.80 x 0.30-0.50 mm.; hysterothecia in cross sectional view 0.30-0.35 mm. deep, subepidermal. Asci cylindrical or clavate, obtusely pointed at apex, 8-spored, 50-60 x 5.0-5.5 μ. Paraphyses filiform, slightly swollen at apex, simple or branched. Ascospores fascicular, filiform, 40-50 x 0.5-0.7 μ, hyaline.

On Cupressineae: *Chamaecyparis obtusa* S. & Z., Japan.
Type Locality: Kawauye-mura, Prov. Mino, Japan on *C. obtusa*.
Illustrations: Bot. Mag. Tokyo, **25**: pl. 2, fig. 1-2. 1911.

The writer has not seen *Lophodermium Chamaecyparisii* but as it is the only described species with good qualifications which has not been examined a modified description is given here for the sake of completeness. *L. Chamaecyparisii* resembles most closely *Lophodermium juniperinum* but asci and spores of the latter are very much larger. *L. juniperinum* is also subcuticular while *L. Chamaecyparisii* is described and illustrated as subepidermal.

EXCLUDED SPECIES

Type material of *Lophodermium Laricis* Dearness and *L. australe* Dearness have been examined by the writer. *L. Laricis* appears to have been based upon a specimen in which the host was wrongly determined. The needles were badly decomposed but resembled closely needles of a white pine, probably *Pinus monticola*. The hysterothecia were indistinguishable from those of *Lophodermium pinastri*. Under *L. australe* Dearness included a large number of gatherings chiefly from the Atlantic Coast States. The specimens examined by the writer contained immature *L. pinastri* and *Hypoderma lethale*. The narrow hysterothecia described by Dearness were, in some cases at least, merely the darkened clypeus lips of *L. pinastri*. In *L. pinastri* the lip region of the clypeus forms subcuticularly and becomes quite conspicuous even during early developmental stages.

Rostrup described a fungus in 1883 which he called *Lophodermium gilvum*. The name has appeared continuously in the literature of the Hypodermataceae since that time although no new report of its occurrence has been made except that in Dearness' (1924) paper. The writer has had the privilege of examining a Rostrup specimen in the herbarium of Dr. J. S. Boyce. It is unquestionably identical with *Naemacyclus niveus* (Pers. ex Fr.) Sacc. The writer has also examined the specimen in Dr. J. S. Boyce's herbarium upon which Dearness based his determination of *L. gilvum*. It likewise proved to be *N. niveus*.

Naemacyclus niveus has been known under a host of synonymous names since Persoon's time. It is widely distributed in Europe although not commonly collected. In America the only record of *N. niveus* appears to be that cited in the Plant Disease Bulletin, Supplement 23:445 (1922), where a mere mention is made of its occurrence on *Pinus* species in Colorado. Dr. J. H. Faull, however, has found it in abundance in nurseries and plantations in Quebec and the writer has obtained it on several *Pinus* species in Massachusetts and California.

Naemacyclus niveus causes a typical needle casting of Pines and the disease is of sufficient importance to warrant careful investigation. At least two morphological forms of *N. niveus* are known and it is probable that strains showing different degrees of pathogenicity also exist.

A description of *Naemacyclus niveus* based upon the writer's observations, has been appended here in order to point out the distinguishing characters of this important species.

Naemacyclus niveus (Persoon ex Fries) Saccardo, Syll. Fung. 8:701 (1899).

Stictis nivea Fries, Syst. Myc. **2**:196 (1822).
Naemacyclus pinastri Fuckel, Symb. Myc. Nachtr. **2**:50 (1873).
Lophodermium gilvum Rostrup in Tidskr. Skovbr. **6**:283 (1883).

Ascocarps scattered, numerous, somewhat rectangular in appearance when partially open, elliptical to subcircular when widely open, at first waxy, dark brown, becoming later concolorous with leaf surface, 0.30-0.50 x 0.23-0.28 mm., under hypodermal layer, opening along stomatal lines, the two halves

of the covering layer becoming widely opened through the tearing of the epidermis across the ends of the ascocarps, the epidermis remaining hinged along sides of ascocarps; disc light straw color; in cross section 0.15-0.17 mm. deep, almost hemispherical before opening; covering layer of colorless pseudoparenchyma 12-18 μ thick in centre, towards margins consists of short loose threads projecting down from hypodermis; hymenium almost flat, 90-100 μ thick; basal plectenchyma colorless, up to 24 μ thick. Asci subcylindrical, 92-115 x 8-10 μ, 8-spored. Paraphyses filiform, straight or branched at apex, often forming a well developed epithecium, the tips of the paraphyses being held together by a reddish orange cementing substance, frequently connected below by hyphal bridges, 80-90 μ long. Ascospores filiform, 1-3 celled at maturity, hyaline, 75-98 x 2-3 μ.

On Abietineae. *Pinus* sp.: Colorado; France.—*Pinus Banksiana* Lamb., Quebec.—*Pinus halepensis* Mill., Tunis.—*Pinus Jeffreyi* Murr., California.—*Pinus mugo* Turra: Denmark; Italy.—*Pinus nigra* Arnold var. *austriaca* Aschers. & Graebn.: Oregon; Denmark; Italy.—*Pinus Pinaster* Ait.: Belgium; France; Italy.—*Pinus ponderosa* Dougl.: California, Massachusetts.—*Pinus radiata* D. Don, California.—*Pinus sylvestris* L.: Massachusetts; Quebec; England; France; Scotland.

Type Locality: Unknown. On *Pinus maritima*.

Distribution: Western Europe, northern Africa, eastern and western North America.

Pure cultures of *Naemacyclus niveus* are easily obtained on agar and ascocarps are produced in abundance. The vigorous growth of *N. niveus* in pure culture is in striking contrast to that obtained in the case of Hypodermataceous fungi.

Several other names which have been reduced to synonymy have already been dealt with in the discussions following the specific descriptions to which they have been referred.

TAXONOMIC DISCUSSION

(A) VON HÖHNEL'S SYSTEM OF CLASSIFICATION

Because of the revolutionary scheme for the classification involving the Hypodermataceae proposed by von Höhnel, his system as relating to this family demands critical analysis. The principal feature underlying his classification is, as has already been noted, the relative position of the ascocarps to the tissues of the host plant with which they are in contact, as

for example, whether they are subcuticular, intraepidermal, subepidermal and so on. These various relationships he used as distinctive family characters. There follows as a result the splitting up of the genera of the Hypodermataceae as generally accepted, species of the same genus often finding a place in different families. Naturally such a disposition called for the reduction of the recognized genera as existing in Lindau's modified Rehm's system to very narrow limits, and for the creation of a large number of new generic names. The genera within von Höhnel's families were separated on the characters of stromata, spore colors, spore shapes, spore septation, paraphyses, asci, ascocarp shapes and parasitism. It is further to be pointed out that his studies were made on a comparatively limited number of species, leaving it to others to fit into his scheme such species as were not at hand.

Since the work recorded in this paper is concerned with the intensive study of a comparatively large number of species lying within narrow limits within the field embraced by von Höhnel's scheme, an opportunity has been afforded of testing out its applicability. The following statements represent the findings in this connection.

(1) Von Höhnel's main basis is grossly artificial, resulting as it does in the wide separation of species obviously closely related as judged by their characters as fungi, and differing almost entirely simply by differences of position of their hysterothecia.

(2) His conception of stroma is not clearly defined. By way of illustration of confusion even in his own mind the case of *Duplicaria* may be cited—referred to by him in one instance as possessing a stroma, and at another time as being without.

(3) On the basis of a single fungal character, species and genera, obviously not related, are brought close together. For example *Naevia* and *Lophodermium* are placed almost in juxtaposition. But *Naevia* is plainly more closely related to the Pezizales and has nothing to do with the Hysteriales.

(4) A very difficult situation ensues in any comprehensive attempt to follow von Höhnel's scheme from the circumstance that he was content to formulate his definitions of genera on types without reference to closely related species. His dis-

tinctions break down when a large number of species not examined by him are the objects of classification. To provide for many of them it would be necessary to set up entirely new, artificially distinguished genera.

(5) His classification is not only artificial in the extreme, but, in its present form, unusable in practice.

(B) THE QUESTION OF THE FURTHER REVISION OF REHM'S SYSTEM OF CLASSIFICATION

The species of the Hypodermataceae as seen by the writer constitute a quite closely related group. They appear to fall quite naturally into the genera as accepted by Rehm and by Lindau, with two or three others that have since been proposed. But there do exist some discrepancies and subdivisions within these genera that eventually may warrant certain realignments. Some of these matters are discussed briefly as referring to the various genera recognized in this paper.

(1) Within the genus *Bifusella* the type species, *Bifusella linearis,* with aparaphysate asci and with broad sterile "sclerotic" areas is clearly set apart by these characters from all other members of the genus.

(2) The genus *Hypoderma* includes seven sharply delimited species on coniferous hosts. The possession of a well organized slit band readily separates *Hypoderma Desmazierii* and *Hypoderma robustum* from the other species. Furthermore the nature of the slit band is strikingly different in these two species.

(3) The species of *Hypodermella* fall naturally into four easily recognized groups, as follows: (a) containing only the type species *Hypodermella Laricis,* (b) including the "nervisequious" species on *Abies,* (c) the *Hypodermella ampla* group on *Pinus* and (d) the *Hypodermella sulcigena* group on *Pinus.*

(4) *Lophodermium* species are rather uniform in their characters but can be separated into two sections on the basis of presence or absence of a well defined slit band.

PART II. BIOLOGY

INTRODUCTION

The biology of the Hypodermataceae of conifers has been a very much neglected field of study. Investigations of life histories have been restricted heretofore almost entirely to field observations. Weir's infection experiments reported in

1916 stand out as a notable exception. Most of the European investigations which deal with the life histories of individual species have been carried out with sufficient accuracy so that one can recognize the species under discussion without question. On the other hand studies dealing with host records and distribution have been limited mostly to the publication of local check lists. On account of newly discovered facts care must be taken to select such information either from the original specimens or from reliable sources such as the works of Hartig (1874), Rostrup (1883, 1891) and Tubeuf (1901). No cytological work has ever been done with the species of Hypodermataceae occurring on conifers; but Likhité (1926) has presented a group of cytological studies, some of which were based upon species of Hypodermataceae occurring on *Crataegus* and *Quercus*.

DISTRIBUTION

HOST RANGES

Species of Hypodermataceae have been reported upon a wide variety of hosts ranging from the brown algae to the Monocotyledons and Dicotyledons. Among the genera studied *Bifusella* and *Hypodermella* are restricted to the Abietineae. *Elytroderma* is a monotypic genus closely related to *Hypodermella* and is known only from the type species on *Pinus*. Species of *Hypoderma* have been reported on Phaeophyceae, Pteridophyta, Gymnospermae, Monocotyledoneae and Dicotyledoneae. Species of *Lophodermium* have been reported from Gymnospermae, Monocotyledoneae and Dicotyledoneae.

Forty-five species of Hypodermataceae occur on the Abietineae as follows: *Bifusella* (5 species on *Abies, Picea* and *Pinus*), *Hypoderma* (7 species on *Abies* and *Pinus*), *Hypodermella* (18 species on *Abies, Larix* and *Pinus*), *Elytroderma* (1 species on *Pinus*) and *Lophodermium* (14 species on *Abies, Cedrus, Larix, Picea* and *Pinus*); three species occur on the Cupressineae, namely, three species of *Lophodermium* distributed among the genera *Chamaecyparis, Juniperus, Libocedrus* and *Thuja*.

GEOGRAPHIC RANGES

The distribution of each species is of necessity limited by the distribution of its hosts. Almost all instances, where Hypodermataceae are restricted to a single host species, are probably due to the fact that they occur in regions where no other

TABLE I

DISTRIBUTION ACCORDING TO CONTINENTS

No.	Species	N.A.	S.A.	Eur.	Afr.	Asia	Oceania
1	Bifusella linearis	X					
2	Bifusella Abietis	X					
3	Bifusella Faullii	X					
4	Bifusella crepidiformis	X					
5	Bifusella striiformis	X					
6	Hypoderma Desmazierii	X		X			
7	Hypoderma robustum	X					
8	Hypoderma pedatum	X					
9	Hypoderma lethale	X					
10	Hypoderma Hedgcockii	X					
11	Hypoderma saccatum	X					
12	Hypoderma Pini	X					
13	Hypodermella Laricis	X		X			
14	Hypodermella limitata	X					
15	Hypodermella lacrimiformis	X					
16	Hypodermella medusa	X					
17	Hypodermella ampla	X					
18	Hypodermella montana	X					
19	Hypodermella lirelliformis			X			
20	Hypodermella mirabilis	X					
21	Hypodermella punctata	X				X	
22	Hypodermella Abietis-concoloris	X					
23	Hypodermella nervata	X					
24	Hypodermella nervisequia			X		X	
25	Hypodermella sulcigena			X			
26	Hypodermella montivaga	X					
27	Hypodermella arcuata	X					
28	Hypodermella concolor	X					
29	Hypodermella conjuncta			X			
30	Hypodermella cerina	X					
31	Elytroderma deformans	X					
32	Lophodermium juniperinum	X		X			
33	Lophodermium cedrinum				X		
34	Lophodermium pinastri	X		X	X	X	X
35	Lophodermium laricinum	X		X		X	
36	Lophodermium nitens	X					
37	Lophodermium uncinatum	X					
38	Lophodermium autumnale	X					
39	Lophodermium Thuyae	X					
40	Lophodermium consociatum	X					
41	Lophodermium lacerum	X					
42	Lophodermium Piceae	X		X			
43	Lophodermium macrosporum			X		X	
44	Lophodermium filiforme	X					
45	Lophodermium durilabrum	X					
46	Lophodermium crassum	X					
47	Lophodermium decorum	X					
48	Lophodermium Chamaecyparisii					X	

closely related host species are present. The majority of "nervisequious" species on *Abies* show peculiarly circumscribed ranges, several species being limited to *Abies balsamea* in northeastern North America, others on *Abies* species in western North America and two species on *Abies alba* in Europe. *Elytroderma deformans* on the other hand is not confined to a single section of the country probably because of the wider overlapping of the ranges of its host plants. It occurs from California to British Columbia and east to Colorado with two eastern stations, one in Northern Ontario and the other in the southeastern United States. Since conifers are of great economic importance they have become widely distributed by artificial planting and records of Hypodermataceae on conifers outside the natural ranges of the host plants are not uncommon.

The ranges given in Table I have been verified as far as possible with the exception of the Asiatic records which have been taken mostly from the work of Shirai and Hara (1927). Type materials of 12 species were European in origin, 34 American, 1 African and 1 Asiatic. There are no doubt a few European and in all probability a large number of Asiatic species still undescribed. The majority of European species have been found elsewhere, but up to the present no American, African or Asiatic species have been found outside of the continent from which they were originally described.

INVESTIGATIONS OF LIFE HISTORIES

HISTORICAL

Prantl (1877) reported the demonstration of parasitism of *Lophodermium pinastri.* His conclusions were based upon a few experiments in which diseased branches were bound on young plants in a seed bed and on branches of an old tree. He claimed that after three weeks small yellow points containing mycelium made their appearance on the inoculated leaves. But the details of his experiments are very meagre and are not at all convincing. Haack's experiments with the same fungus were more satisfactory (1911). But carefully controlled experiments, in which the plants have been protected against unfavorable climatic conditions have never been performed with *L. pinastri.* An interesting but questionable point was raised by Tubeuf (1901) in connection with his work on *L. pinastri* to the effect that a lessened turgescence of the needles seemed

necessary before infection would take place. Mer (1912), studying *Hypodermella nervisequia,* applied a somewhat similar explanation to account for the long period, sometimes several years in duration, which frequently occurs before the first appearance of any visible evidence of disease. He considered the fungus capable of entering the young needles and of resting in an inert state in the substomatal chamber and in the neighboring parenchyma cells. Then, when unfavorable conditions in the plant weakened the needles, the parasite was enabled to make headway. He further experimented in order to prove that a weakened condition was necessary before infection would take place. His method was to grow the seedling under adverse conditions or to transplant it, his contention being that it would then be weaker and therefore more susceptible. Another series of experiments, claimed by him to have been successful, aimed to arrest the course of disease by transplanting diseased seedlings into richer soil and also by chemically feeding the plants.

The only really satisfactory infection experiments with any of the Hypodermataceae were those of Weir (1916) using *Elytroderma deformans*. His inoculations were carefully controlled and infections obtained were as high as 100% in some cases.

In addition to experimental studies much can often be learned of life histories by careful observations of the fungi under natural conditions. Field observations of the time of ascospore discharge give a clue to the time of infection, because so far as is known infection takes place in no other way than by ascospores. By following the course of the development of the disease as evinced by the discoloration of the host needles, noting especially the time of appearance of discoloration, first appearance of pycnidia and hysterothecia and period and duration of sporulation, fairly reliable conclusions can be reached with regard to the parasitism of the species under observation.

The most destructive species are those which are capable of completing their life cycles in one year. *Elytroderma deformans, Hypodermella sulcigena, Hypodermella concolor, Hypoderma Desmazierii* and *Lophodermium laricinum* have a one year cycle and with the exception of the last two are examples of species known to cause serious disease.

The works of Hartig (1874), Rostrup (1883, 1891), Tubeuf (1888, 1901), Lagerberg (1910, 1913), Fron (1911), Haack (1911), Mer (1911, 1912), Graves (1913), Weir (1916), Schmitz (1923), Wilson (1924) and Hagem (1926) include valuable field observations on a number of species; but there are still many baffling biological problems to be solved, and corroboration of field studies by the artificial production of disease has yet to be given for the majority of species of Hypodermataceae.

NECESSITY FOR CULTURES

Carefully controlled infection experiments are necessary to establish the connections between the hysterothecial stages and the pycnidial stages found associated with them. In the majority of cases reported the pycnidia are unquestionably "stages" in the life cycles of Hypodermataceous fungi, yet with five or six exceptions, positive proof is still lacking. There are, on the other hand, examples such as that of *Hendersonia acicola* Tubeuf reported by Lagerberg (1910) as the imperfect stage of *Hypodermella sulcigena* in which the genetic relationships assumed are extremely improbable.

Infection experiments are also needed to prove the pathogenicity of the different species of Hypodermataceae. At the present time the literature contains reference to only one species adequately established as parasitic, namely, *Elytroderma deformans*. In such experiments, however, one must guard carefully against confusing the effects due to adverse climatic conditions with those brought about by the fungus. Thus in Europe wide differences of opinion are to be found regarding the parasitism of *Lophodermium pinastri*. Scores of workers have published on this subject, some considering it the primary cause of needle cast of pines, others regarding it merely as a saprophyte whose presence is indicative of a weakening of the plant caused by some other agency. It is of course true that many more or less distinct morphological variants of *L. pinastri* are known, and it is possible that certain of them are pathogenic. The proof, however, is still lacking. As a part of the procedure involved cultures should be made with host and fungus material of different origins in various localities in order to determine whether the differences reported are due to the presence of strains in the host plant or in the

fungus organism or to dissimilar climatic or distributional factors. Lagerberg (1913) has very aptly summarized the literature of the *L. pinastri* controversy and has emphasized the value of controlled culture experiments.

Taxonomically, cultures are valuable in that cross inoculations can be performed on closely related host species with inoculum from a single host. There are several groups of Hypodermataceous species which the author has preferred to retain as distinct from one another chiefly because of morphological differences in the shape of the hysterothecium or differences in the position of the hysterothecium within the host tissues. So far as is known these distinctions are always valid, yet it is possible that since these closely related species are always found on different hosts they may represent merely host variants of the same species. The only cross inoculations from one host to another are those reported for *Hypoderma Desmazierii* by the writer. Infections from *Pinus Strobus* to *P. Strobus, P. Banksiana* and *P. resinosa* were successfully demonstrated. On these three hosts the fungus retained the same relative position in the host tissue, the same shape and the well-marked slit band characteristic of *H. Desmazierii* on its most frequent host, *P. Strobus*. To this extent at least the position of the hysterothecium in the host tissue has been demonstrated to be diagnostic of a species, and there is some justification, therefore, for maintaining certain closely related forms as distinct species.

CULTURE TECHNIQUE

In experiments reported in the literature three methods have been employed in culture experiments: (a) tying of diseased twigs on healthy branches, (b) planting of healthy plants in diseased areas and (c) spraying with water or sugar solutions containing spores (Weir, 1916). In most of the experiments described below, Hubert's technique, originally designed for rust infection work, was employed. Inoculum consisted of diseased twigs which were collected and placed in moist chambers until spores were discharging freely. The inoculum was tied above and below healthy needles, and the inoculated portion of the host was slipped into a celluloid cylinder which was then plugged at both ends with moist sphagnum. The inoculum was left in the cylinder for several days and then

removed. Infection was also attempted using scrapings of asci and spore decoctions in water. In a few cases mycelium from pure cultures on agar served as inoculum. In the successful experiments, however, either celluloid cylinders were employed or the inoculum was merely tied on the branches without protection. The other methods might have yielded satisfactory results but they were not tried out.

All of the experiments listed here were carried out on Bear Island and neighboring islands situated in Lake Timagami, Ontario.

ORIGINAL INFECTION EXPERIMENTS

TABLE II

SUMMARY OF ORIGINAL INFECTION EXPERIMENTS

INOCULUM	NUMBER OF INOCULATIONS	NUMBER SUCCESSFUL
Bifusella Faullii	117	?
Hypoderma Desmazierii	120	7
Hypodermella Laricis	9	5
Hypodermella concolor	63	25
Hypodermella nervata	126	8
Bifusella crepidiformis	66	0
Hypodermella ampla	10	0
Hypodermella mirabilis	11	0
Lophodermium autumnale	6	0
Lophodermium filiforme	8	0
Lophodermium juniperinum	6	0
Lophodermium lacerum	11	0
Lophodermium laricinum	4	0
Lophodermium nitens	95	0
Lophodermium Piceae	17	0
Lophodermium pinastri	40	0
Lophodermium Thuyae	16	0

BIFUSELLA FAULLII Darker—A few inoculations yielded rather inconclusive results. The number of needles found infected in each case was always so small that the value of the experiments appeared questionable. Insofar as one could determine from the experiments they bore out field observations, pycnidia developing on one year old needles one year after inoculation and hysterothecia two years after inoculation.

HYPODERMA DESMAZIERII Duby—A total of 120 inoculations on *Pinus Strobus, Pinus Banksiana, Pinus resinosa* and *Tsuga canadensis* showed positive results on the three species of pine. Inoculum was obtained from *P. Strobus*. Inoculations by means of spores discharged within celluloid tubes failed to produce infection; positive results followed only from

those inoculations in which the inoculum was tied on the experimental branches and left over winter. In addition to the needles which bore hysterothecia there were many brown ones without fruiting bodies. The results were of special interest in that the hysterothecia produced on *P. Banksiana* and *P. resinosa* retained the characters possessed by the fungus as it occurs on *P. Strobus*. The infections reported in Table III include only the successful inoculations. Although infections were not heavy there was no question about their authenticity. The experiments were all set up in the forest where the fungus has never been found. *H. Desmazierii* on *P. Banksiana* is known in America only from these experiments and but a single tree of *P. resinosa* has ever been observed as a natural host.

TABLE III

INOCULUM—*Hypoderma Desmazierii* Duby on *Pinus Strobus* L.

Inoculation number	Date of inoculation	Host inoculated	Date harvested	No. of needles inoculated	No. of needles infected	% of needles infected
652	Sept. 19, 1926	Pinus Banksiana	Sept. 1, 1927	..	1	..
654	Sept. 19, 1926	Pinus Banksiana	Sept. 12, 1927	..	1	..
745	Sept. 1, 1927	Pinus Strobus	Sept. 5, 1928	150	11	7
747	Sept. 1, 1927	Pinus Banksiana	Aug. 20, 1928	68	2	3
749	Sept. 1, 1927	Pinus Banksiana	Aug. 20, 1928	..	1	..
751	Sept. 1, 1927	Pinus resinosa	Sept. 5, 1928	334	19	6
752	Sept. 1, 1927	Pinus resinosa	Sept. 5, 1928	64	5	7

HYPODERMELLA LARICIS v. Tubeuf—The inoculum used in this series of experiments was collected by Dr. J. H. Faull on *Larix laricina* (Du Roi) Koch at Moccasin Lake, Klock Township, Ontario, Sept. 3, 1924. The ascospores were not yet mature but in the following spring nearly all were found to have been discharged. Infection took place on five out of the nine inoculated branches. Growing alongside and under these inoculations there were 21 infected spur shoots in addition to those occurring on the inoculated portions. Since the inoculum was merely placed in cheese-cloth bags which were tied over the ends of branches, it was free to infect any branch in the neighborhood. But it was not found to carry beyond a circle of about 8 feet in radius although the inoculated branches were at a distance of about 4 to 5 feet above the surface of the ground.

A number of features reported in Table IV should be verified. For example, during the year 1925 no sign of the disease appeared although many of the needles showed a marked yellow color. In 1926 the needles of the infected spur shoots turned a reddish brown color and a crop of pycnidia developed about the first of August, followed later by hysterothecia which were still immature at the time of harvesting. There appeared to be no doubt of the ability of the fungus to parasitize the Larch since the experiments were conducted on an island situated in the middle of Lake Timagami, Ontario, considerably removed from the nearest known natural infections. In Ontario only two localities have been reported for the fungus, one on the mainland near Lake Timagami about two miles west of the peat bog where the inoculations were performed and the other at Moccasin Lake about 30 miles to the north. The latter infection was reported by Dr. Faull as of considerable extent but the former was limited to a very few trees in a small sheltered peat bog.

Occasionally only a portion of the needles of a spur shoot became diseased. In a few instances diseased spur shoots

TABLE IV

INOCULUM—*Hypodermella Laricis* v. Tubeuf on *Larix laricina* (Du Roi) Koch

HOST INOCULATED—*Larix laricina*

Inoculation number	Inoculum tied on branches	Inoculum removed	Date harvested	No. of spur shoots inoculated	No. of spur shoots infected	% of spur shoots infected
481	Sept. 16, 1924	Fell off	Sept. 14, 1926	..	..	..
482	Sept. 16, 1924	during	Sept. 14, 1926	..	..	..
483	Sept. 16, 1924	winter	Sept. 14, 1926	..	..	..
484	Sept. 16, 1924	June 8, 1925	Sept. 14, 1926	47	2	4
485	Sept. 16, 1924	June 8, 1925	Sept. 14, 1926	20	1	5
486	Sept. 16, 1924	June 8, 1925	Sept. 14, 1926	Dead	..	..
487	Sept. 16, 1924	June 8, 1925	Sept. 14, 1926	42	1	2
488	Sept. 16, 1924	June 8, 1925	Sept. 14, 1926	54	3	6
489	Sept. 16, 1924	June 8, 1925	Sept. 14, 1926	97	17	18

produced new needles in the following spring. These in turn became infected but whether their infection was brought about by a mycelium hibernating in the spur shoot or by ascospores from the diseased needles of the preceding year was not known.

HYPODERMELLA CONCOLOR (Dearness) Darker—Inoculum of *Hypodermella concolor* from *Pinus Banksiana* was used for

TABLE V

INOCULUM—*Hypodermella concolor* (Dearn.) Darker on *Pinus Banksiana* Lamb.

HOST INOCULATED—*Pinus Banksiana*

Inoculation number	Inoculum collected	Date of inoculation	Cylinder on branch (days)	Date harvested	No. of needles harvested	No. of needles infected	% of needles infected
493	July 5, 1925	July 7, 1925	11	....	..	..	..
494	July 5, 1925	July 7, 1925	11	July 23, 1926	34	1	3
495	July 5, 1925	July 7, 1925	11	July 23, 1926	56	17	30
496	July 5, 1925	July 7, 1925	11	....	..	..	..
497	July 5, 1925	July 7, 1925	11	....	..	..	..
498	July 5, 1925	July 7, 1925	11	....	..	..	..
499	July 5, 1925	July 9, 1925	9	July 23, 1926	56	56	100
500	July 5, 1925	July 9, 1925	9	July 23, 1926	36	18	50
501	July 5, 1925	July 9, 1925	9	....	..	..	..
502	July 5, 1925	July 9, 1925	9	July 23, 1926	28	4	14
503	July 5, 1925	July 9, 1925	9	July 23, 1926	16	15	94
504	July 5, 1925	July 9, 1925	9	....	..	..	..
505	July 5, 1925	July 9, 1925	9	July 23, 1926	32	10	31
506	July 5, 1925	July 9, 1925	9	July 23, 1926	30	9	30
507	July 5, 1925	July 9, 1925	9	July 23, 1926	10	7	70
508	July 5, 1925	July 9, 1925	9	....	..	..	..
510	July 5, 1925	July 11, 1925	..	July 6, 1926	64	23	36
511	July 5, 1925	July 11, 1925	..	July 23, 1926	4	3	75
512	July 5, 1925	July 11, 1925	..	July 23, 1926	12	7	58
513	July 5, 1925	July 11, 1925	..	July 23, 1926	20	14	70
514	July 5, 1925	July 15, 1925	9	....	..	..	..
515	July 5, 1925	July 15, 1925	9	....	..	..	..
516	July 5, 1925	July 15, 1925	9	....	..	..	..
517	July 5, 1925	July 15, 1925	9	July 23, 1926	36	3	8
518	July 5, 1925	July 15, 1925	9	July 23, 1926	28	3	11
519	July 5, 1925	July 15, 1925	9	....	..	..	..
520	July 5, 1925	July 17, 1925	13	July 23, 1926	30	2	7
521	July 5, 1925	July 17, 1925	13	July 23, 1926	14	10	71
522	July 5, 1925	July 17, 1925	13	July 23, 1926	38	3	8
523	July 5, 1925	July 17, 1925	7	....	..	..	..
524	July 5, 1925	July 17, 1925	7	July 23, 1926	32	1	3
525	July 5, 1925	July 17, 1925	13	July 23, 1926	58	27	47
613	July 25, 1926	July 26, 1926	14	July 8, 1927	34	9	26
614	July 25, 1926	July 26, 1926	14	July 8, 1927	24	6	25
615	July 25, 1926	July 26, 1926	14	....	..	..	..
622	July 25, 1926	July 26, 1926	14	July 8, 1927	24	13	54
623	July 25, 1926	July 26, 1926	14	July 8, 1927	80	10	13
624	July 25, 1926	July 26, 1926	14	July 8, 1927	110	16	15

63 inoculations on *Pinus Banksiana, P. resinosa, P. Strobus* and *Picea glauca*. Out of 38 set up on *Pinus Banksiana* 25 were successful (See Table V). Percentages of infection were

based upon the number of needles hanging on the twigs at the time of harvesting. Since needle casting is a characteristic of this disease, the percentages recorded indicate figures considerably below the true values. Inoculations on *P. resinosa, P. Strobus* and *Picea glauca* were unsuccessful.

Infection took place in July on the youngest needles. There was no discoloration of the needles during the current season; but during late May and early June of the following year the needles began to turn brown and hysterothecia were mature in July.

HYPODERMELLA NERVATA Darker—Eight infection experiments on *Abies balsamea* out of a total of 126 gave positive results. Infection of young tender needles took place in July but during the first season there was no evidence of infection and the needles remained green until the following spring. In June the needles began to discolor and by the middle of July the

TABLE VI

INOCULUM—*Hypodermella nervata* Darker on *Abies balsamea* (L.) Mill.

HOST INOCULATED—*Abies balsamea*

Inoculation number	Date of inoculation	Cylinder on branch (days)	Date of harvesting	No. of needles inoculated	No. of needles infected	% of needles infected
265	July 11, 1924	6	June 7, 1926	..	2	..
266	July 11, 1924	6	June 7, 1926	..	3	..
267	July 11, 1924	6	June 7, 1926	..	14	..
271	July 13, 1924	5	Sept. 19, 1926	117	4	3
272	July 13, 1924	5	Sept. 19, 1926	114	3	3
273	July 13, 1924	5	Sept. 19, 1926	169	21	12
274	July 13, 1924	5	Sept. 19, 1926	82	8	10
275	July 13, 1924	5	Sept. 19, 1926	94	6	6

pycnidia had made their appearance. During August and September hysterothecia began to appear and in the following spring, two years after infection had taken place, the mature ascospores were discharged.

In addition to the experiments listed above all of the inoculations with *Lophodermium laricinum* and *Lophodermium nitens*, both of which appear to be saprophytic, showed infection. But the control needles were also uniformly infected so that no conclusions could be drawn from the results.

SPORE GERMINATION

In the spore germinations recorded by the writer, the technique adopted has been kept as simple as possible and at the same time as uniform as possible. Clean cover glasses, sterilized by flaming with alcohol, were inverted in a moist chamber over hysterothecia which were discharging spores freely. The cover glasses were then placed over "Van Tieghem" cells containing a few drops of water, some of which soon condensed on the cover glasses. Preparations made in this manner without further precautions remained sterile throughout the periods required for germination. In a few instances ascospores were germinated in nutrient solutions and on agars but the results did not appear to justify extensive work along this line.

Species which are known to be most parasitic in their action, e.g. such species as *Hypodermella Laricis* and *Hypodermella concolor,* do not germinate freely in distilled water. If a germ tube is sent out from an ascospore of one of these species its development is soon arrested. On the other hand, *Lophodermium Piceae,* a mildly parasitic species, grows quite freely in distilled water. In all species in which germination has been studied the formation of the germ tube has been preceded by the development of a septum across the middle of the ascospore. As a rule not more than one germ tube develops from each ascospore, but occasionally there is one from each half of the spore. More rarely, especially in the germination of Lophodermium spores, several tubes arise from each half of the spore. In such instances secondary septa frequently develop in each half of the spore, so that each germ tube appears to be the product of a definite portion of the ascospore.

Because of their taxonomic importance, features of spore germination considered of sufficient interest to warrant attention have been noted among the characters appended under the specific descriptions. All species that have been observed during germination have been recorded in detailed illustrations. (See description of plates, pp. 117-127.)

PATHOLOGIC AND ECONOMIC IMPORTANCE

PATHOLOGIC EFFECTS

Pathologic effects on the host plants are distinctive for each species of Hypodermataceae. Portions of needles, entire needles or groups of needles may be killed and even the stem may

be invaded and stimulated to form witches' brooms. *Hypodermella limitata* and *Hypodermella lacrimiformis* destroy short sections of the middle portions of individual needles and eventually the whole tip beyond the killed portion dies. *Hypodermella nervata* and *Bifusella Faullii* usually attack the whole needle and when infection is heavy it is not uncommon to find the whole year's growth destroyed. *Hypodermella concolor* causes such severe blighting that after one or two years of heavy defoliation the tips of the twigs are killed and the whole branch may eventually die. Needles attacked by *H. concolor* and *Elytroderma deformans* frequently exhibit a tufted and dwarfed appearance. *E. deformans* also invades the branch tissues and stimulates them to produce witches' brooms which may attain immense proportions. Young Pines in which the main branches all become converted into brooms are usually killed. Fron (1911) reported that he found the mycelium of *Hypoderma Desmazierii* capable of invading young stems and branches and v. Tubeuf (1901) made the same claim for *Lophodermium pinastri*.

Premature leaf casting is characteristic of a number of species, especially of those belonging to the Lophodermium group. *Lophodermium pinastri* and *Lophodermium Piceae* are commonly associated with the casting of old needles. *Hypodermella ampla* and *Hypodermella concolor* are examples of species causing casting of one year old needles; these fall to the ground at or slightly before maturity of the hysterothecia. In other instances the diseased needles tend to cling to the branches long after the hysterothecia have discharged their spores. Needles destroyed by *Lophodermium filiforme* and *Bifusella crepidiformis* remain adherent to the branches until they are weathered away. Larch needles which normally fall at the end of the growing season remain indefinitely attached to the spur shoots when killed by *Hypodermella Laricis*.

ECONOMIC IMPORTANCE

Needle casting is most important when young needles are attacked. Casting of older needles is usually associated with normal leaf fall and does little or no injury to the suscept. Defoliation is rarely severe enough to kill a tree except in the case of very young seedlings. Nevertheless, the infection may be so severe that the annual growth may be seriously

inhibited. Young trees, under these circumstances, become much suppressed and in the native balsam fir forests such plants are unable for some time to get above the ground cover.

Stem and twig invasion, however, may result in the ultimate destruction of the portion attacked. *Elytroderma deformans* causes brooming and distortion capable of killing trees of all age classes.

A few species of Hypodermataceae cause serious diseases of nursery stock, especially in Europe. In forests and plantations several species are economically important. The species of the genus *Hypodermella* are without exception worthy of more detailed study because every species appears to be an active parasite.

CONTROL

ARTIFICIAL CONTROL

The practice of artificial control of Hypodermataceae has been limited almost entirely to the control of diseases caused by *Lophodermium pinastri* and *Hypoderma Desmazierii*. Both of these species, however, are considered to be but mildly parasitic and it is very probable that their prevalence is largely controlled by climatic factors. It is not surprising, therefore, that the results of attempts to control them are at variance. The experimental investigations carried on in this field have been mostly the work of Tubeuf (1901). His recommendations have been carefully summarized by Neger (1924). Among the numerous measures suggested for the control of *L. pinastri,* one of the most commonly advocated has been the use of Bordeaux mixture. Manshard (1929), in a recent paper, has given advice for the successful application of this spray. Hilitzer (1929) also tested out Bordeaux but he claimed to have found it almost useless for the control of *L. pinastri.* Unfortunately no attempts have ever been made to control such strongly parasitic forms as *Elytroderma deformans, Hypodermella concolor* and *Hypodermella Laricis.*

NATURAL CONTROL

A large number of saprophytic fungi are known to follow up secondarily after infection by Hypodermataceae and prevent the Hypodermataceous species from reaching a fruiting condition. Lagerberg (1928) pointed out such an association in the case of *Naevia piniperda* Rehm, a fungus which develops

on needles attacked primarily by *Lophodermium macrosporum*. No one in America has given serious attention to these organisms although Dearness has made casual mention of one species. For the most part they are insignificant in appearance and yet they are an important factor in the control of certain dangerous parasitic species. This point is especially significant in dealing with forest fungi where artificial control is impracticable. It is possible that the importation of suitable saprophytic organisms into regions having epidemic outbreaks of certain species of Hypodermataceae might well be advocated as a measure capable of bringing about partial control at least.

The relationship between the Hypodermataceous fungus and the saprophytic species appears to be a sort of commensalism such as reported by Stevens (1918) for certain fungi associated with species of *Meliola*. It is a commensalism, however, only after the Hypodermataceous species has prepared the substrate for the secondary species.

Many fungi, probably wholly saprophytic, are found in association with species of Hypodermataceae, but the following incomplete list includes only species which are known to be sufficiently vigorous as to act as a check on the Hypodermataceous species.

Hypodermataceous Species	Secondary Species
Bifusella Faullii	*Leptosphaeria* sp. *Lophodermium autumnale* *Stegopezizella balsameae*
Hypoderma lethale	*Pezizella minuta* (Dearness, 1926)
Hypoderma robustum	*Lophodermium autumnale* *Lophodermium consociatum*
Hypodermella mirabilis	*Leptosphaeria* sp. *Lophodermium autumnale* *Stegopezizella balsameae*
Hypodermella nervata	Several unidentified fungi
Hypodermella punctata	*Lophodermium autumnale*
Lophodermium filiforme	*Naevia piniperda*
Lophodermium macrosporum	*Naevia piniperda* (Lagerberg, 1928) *Pyrenochaetina Lophodermii* (Siemaszko, 1925)
Lophodermium Piceae	*Cladosporium herbarum*

Hendersonia, when found associated with *Hypodermella sulcigena* and *Hypodermella montivaga,* is also probably sec-

ondary in appearance. It is possible that *Daedalea nervicola* Hazslinsky belongs likewise in this category.

SUMMARY

1. The taxonomy and biology of 48 species of Hypodermataceae occurring on conifer needles are discussed in the present paper.
2. The following conifers are hosts: *Abies* (14 species restricted to this genus, 1 also on *Picea*), *Chamaecyparis* (1 species restricted to this genus and 1 also on *Libocedrus* and *Juniperus*), *Cedrus* (1 species), *Larix* (2 species), *Libocedrus* (1 species, also on *Chamaecyparis* and *Juniperus*), *Juniperus* (1 species, also on *Chamaecyparis* and *Libocedrus*), *Picea* (4 species restricted to this host and 1 also on *Abies*), *Pinus* (23 species) and *Thuja* (1 species).
3. Twenty-four species are described as new: on *Abies* (10 species), *Picea* (3 species) and *Pinus* (11 species).
4. A new genus, *Elytroderma,* is proposed for *Hypoderma deformans* Weir.
5. One form and one variety are raised to specific rank, namely *Hypodermella montivaga* f. *concolor* Dearness and *Hypoderma robustum* var. *Pini* Dearness.
6. Six species, *Lophodermium gilvum, Lophodermium australe, Lophodermium Laricis, Lophodermium lineatum, Hypoderma Namyslowski* and *Scolecodothis pinicola* are not regarded as valid species by the writer and have been reduced to synonymy.
7. *Lophodermellina pinastri,* a name based by v. Höhnel on *Lophodermium pinastri* belongs according to the description and to the specimens so named by von Höhnel to *Lophodermium Piceae* and not to *L. pinastri.*
8. Certain features of the imperfect stages of the Hypodermataceae are noted for the first time and in some instances the imperfect stages are used taxonomically.
9. Spore germination is described for those species in which it is considered of taxonomic value. Although the ger-

mination in distilled water is probably somewhat abnormal it is nevertheless remarkably constant for a given species.

10. Successful infection experiments are reported with the following pathogenic species: *Bifusella Faullii, Hypoderma Desmazierii, Hypodermella Laricis, Hypodermella concolor* and *Hypodermella nervata.*

11. Attention is called to the occurrence of certain saprophytic species of fungi which follow up secondarily after infections caused by Hypodermataceous species; it is suggested from observations on the phenomena of their occurrence that they may play a part in control of the Hypodermataceous organisms.

12. The text is accompanied by a series of original illustrations, with special attention being given to North American species.

CONSPECTUS OF GENERA AND SPECIES

(Arranged according to host genus)

(The number following the specific name refers to the serial number given to the specific description in the body of the paper.)

On ABIES:

On CEDRUS:

BIBLIOGRAPHY

BIRULA, I., Z. DABROWSKI & L. KRÓWLIKOWSKI. (1928). Grózny szkodnik Limby (Pinus cembra) Hypoderma Namyslowski sp. nova. Ein gefährlicher Schädling der Arve (P. cembra) Hypoderma Namyslowski sp. nova). (Roczn. Nauk. Rolnicz. Lesn. **20**:35-41.)

BISBY, G. R. (1923). The literature of the classification of the Hysteriales. (Trans. Brit. Myc. Soc. **8**:176-189.)

BOYCE, J. S. (1927). Lophodermium infectans Mayr a synonym of Hypoderma robustum Tubeuf. (Mycologia, **19**:284-285.)

————(1928. Lophodermium abietis on Pseudotsuga taxifolia. (Mycologia, **20**:301-302.)

BRUNCHORST, J. (1892). Nogle norske skovsygdomme. (Bergens Museums Aarbog, **8**:1-11.)

CHEVALLIER, F. F. (1822). Essai sur les Hypoxylons Lichénoides. (Jour. de Physique, **94**:28-61.)

————(1826). Flore générale des environs de Paris, I. 676 pp.

DEARNESS, JOHN (1924). New and noteworthy fungi—III. (Mycologia, **16**:143-176.)

————(1926). New and noteworthy fungi—IV. (Mycologia, **18**:236-255.)

————(1928). New and noteworthy fungi—V. (Mycologia, **20**:235-246.)

DUBY, J. E. (1861). Mémoire sur la tribu des Hystérinées de la famille des Hypoxylées (Pyrénomycètes). (Mém. Soc. Phys. et Hist. Nat. Genève, **16**:15-70.)

FRIES, ELIAS (1823). Systema mycologicum, 2. Sect. **2**:275-620.

FRON, G. (1911). Maladie du Pinus Strobus determinée par Lophodermium brachysporum Rostrup. (Bull. Soc. Myc. France, **27**:44-46.)

GRAVES, A. H. (1913). Notes on diseases of trees in the southern Appalachians I. (Phytopath. **3**:129-139.)

GROVE, W. B. (1928). An instructive Pyrenomycete (Henriquesia). (Jour. Bot. **66**:136-138.)

HAACK, G. (1911). Die Schüttepilz der Kiefer. (Zeitschr. Forst.- u. Jagdwesen, **43**:329-357, 402-423, 481-505.)

HAGEM, OSCAR (1928). Lophodermium-Schütte in West-Norwegen. (Zeitschr. Pflanzenkr. u. Pflanzenschutz, **38**:193-208.)

HARTIG, ROBERT (1874). Wichtige Krankheiten der Waldbäume. 127 pp.

HARTLEY, C. (1913). The blights of coniferous nursery stock. (U. S. Dept. Agric. Bull. **44**. 21 pp.)

HILITZER, ALFRED (1929). Monografická studie o českých druzích řádu Hysteriales a o sypavkách jimi působených (Vědecké spisy vydávané Československou Akademii Zemědělskou, **3**:1-162.)

HÖHNEL, FRANZ VON (1917[1]). System der Phacidiales v. H. (Ber. Deutsch. Bot. Ges. **35**:416-422.)

———(1917[2]). Mycologische Fragmente. cxxxix. Ueber die Gattung Coccomyces de Notaris. (Ann. Myc. **15**:322-323.)
———(1917[3]). Mycologische Fragmente. cxxxiii. Ueber die Gattung Lophodermium Chevallier. (Ann. Myc. **15**:311-313.)
———(1917[4]). Fragmente zur Mykologie. 1008. Ueber Phacidium Piceae Fuckel. (Sitzb. Akad. Wiss. Wien Math.-Naturw. Kl. **126**(1):296.)
———(1917[5]). Mycologische Fragmente. cxxxvi. Ueber Rhytisma lineare Peck. (Ann. Myc. **15**:318-319.)
———(1918). Mycologische Fragmente. cclxxii. Ueber die Hysteriaceen. (Ann. Myc. **16**:145-154.)
Lagerberg, Torsten (1910). Om gråbarrsjukan hos tallen des orsak och verkningar. (Skogs. Tidskr. **8**:221*-242*, 357*-382*.)
———(1914). En abnorm barrfällning hos tallen. (Medd. Stat. Skogsförs. **10**(1913):139-178.)
———(1928). Uber Naevia piniperda Rehm. (Svensk Botanisk Tidskr. **22**:282-288.)
Lamarck, J. de & A. P. de Candolle (1805). Flore française. 3rd. Ed. 2. 600 pp.
Likhitè, V. (1926). Recherches sur le développement et la biologie de quelques Ascomycètes. (Rev. Gén. Bot. **38**:5-30, 95-106.)
Lind, J. (1913). Danish fungi as represented in the herbarium of E. Rostrup. 650 pp.
Lindau, G. (1896). Hysteriineae in Engler & Prantl, Natürl. Pflanzenfam. **1**(1):265-278.
Lohman, M. L. (1931). A study of Glonium parvulum in culture. (Papers Mich. Acad. Sci. **13**:141-157.)
Manshard, E. (1929). Lässt sich die Kupferkalkbrühe bei der Schüttebekämpfung ersetzen. (Forstarchiv, **5**:160.)
Mayr, H. (1890). Die Waldungen von Nordamerika. 448 pp.
Mer, E. (1910). Le Lophodermium macrosporum parasite des aiguilles d'Épicéa. (Rev. Gén. Bot. **22**:297-336.)
———(1912). Le Lophodermium nervisequum parasite des aiguilles de Sapin. (Rev. Eaux et Forêts, **51**:481-493.)
Neger, F. W. (1924). Die Krankheiten unserer Waldbäume und der wichtigsten Gartengehölze. Zweite Auflage. 296 pp.
De Notaris, G. (1847). Prime linee di una nuova disposizione d' Pirenomiceti Isterini. (Giorn. Bot. Ital. **2**:5-52.)
Overholts, L. O. (1924). Mycological notes for 1921-22. (Mycologia, **16**:233-239.)
Peck, C. H. (1873). Report of the Botanist. (Annual Rept. N. Y. St. Mus. Nat. Hist. **25**(1871):57-123.)
Persoon, D. C. H. (1801). Synopsis methodica fungorum. 706 pp.
Prantl, K. (1877). Hysterium pinastri Schrad. als Ursache der Schüttekrankheit der Kiefer. (Flora, N. S. **35**:333-336.)
Rehm, H. (1886). Revision der Hysterineen im Herb. Duby. (Hedwigia, **25**:173-202.)

————(1887). Hysteriaceae in Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz. 2nd. Ed. **3**:1-56.

RIDGWAY, ROBERT (1912). Color standards and color nomenclature. 43 pp. and 53 plates.

ROSTRUP, E. (1883). Fortsatte Undersøgelser over Snyltesvampes Angreb paa Skovtraeerne. (Tidsskr. Skovbrug, **6**:199-300.)

————(1891). Undersøgelser over Snyltesvampes Angreb paa Skovtraeer i 1883-1888. (Tidsskr. Skovbrug, **12**:175-238.)

SACCARDO, P. A. (1883). Hysteriaceae in Syll. Fung. **2**:721-813.

SCHMITZ, HENRY (1923). Leaf cast of Larix occidentalis by Hypodermella laricis in north Idaho. (Phytopath. **13**:505-506.)

SCHRADER, H. A. (1799). Plantae cryptogamicae novae, rariores aut minus cognitae. (Schrad. Jour. Bot. **2**:55-70.)

SHIRAI, M. & K. HARA (1927). A list of Japanese fungi hitherto known. 448 pp.

SKORIC, V. (1923). Zur Kenntnis der Ursache der Schütte der Nadelhölzer. (Forstl. Blätter Jugoslav. Forstverein, **3**:127-137.)

SMITH, A. LORRAIN & J. RAMSBOTTOM (1920). New or rare microfungi. (Trans. Brit. Myc. Soc. **6**:365-374.)

STEVENS, F. L. (1918). Some meliolicolous parasites and commensals from Porto Rico. (Bot. Gaz. **65**:227-249.)

SYDOW, H. & F. PETRAK (1924). Zweiter Beitrag zur Kenntnis der Pilzflora Nordamerikas, insbesondere der nordwestlichen Staaten. (Ann. Myc. **22**:387-409.)

TODE, HEINRICH JULIUS (1784). Beschreibung des Venusschwammes (Hysterium). (Schrift. Berlin. Ges. Naturf. Freunde, **5**:53-55.)

————(1791). Fungi Mecklenburgenses. Fasciculus II. 64 pp.

TUBEUF, CARL V. (1888). Beiträge zur Kenntniss der Baumkrankheiten. 61 pp.

————(1895[1]). Demonstration von Lärchenzweigen. (Bot. Centralbl. **61**:48-49.)

————(1895[2]). Pflanzenkrankheit durch kryptogame Parasiten verursacht. 599 pp.

————(1901). Studien über die Schüttekrankheit der Kiefer. (Arb. Biol. Abth. Forst.- u. Landw. Kaiserl. Gesundh. **2**:1-160.)

————(1908). Die Nadelschütte der Weymouthskiefer. (Naturw. Zeitschr. Forst.- u. Landw. **6**:326-330.)

————(1910). Kultur parasitischer Hysteriaceen. (Naturw. Zeitschr. Forst.- u. Landw. **8**:408-411.)

————& WM. G. SMITH (1897). Diseases of plants induced by cryptogamic parasites. 598 pp.

VUILLEMIN, P. (1911). Remarques sur une maladie du Pin Weymouth. (Compt. Rend. Acad. Sci. Paris, **152**:1497-1498.)

WANIN, S. I. (1925). Ueber zwei neue Pilze, welche im Leningrader Gouvernement junge Kiefern beschädigen. (Mitteilung. Leningrad. Forstinst. **32**:187-188.)

WEIR, J. R. (1913). An epidemic of needle diseases in Idaho and western Montana. (Phytopath. 3:252-253.)
————(1916). Hypoderma deformans, an undescribed needle fungus of the western Yellow Pine. (Jour. Agric. Res. 6:277-288.)
WIBEL, A. W. E. C. (1799). Primitiae florae werthemensis. 372 pp.
WILSON, MALCOLM (1920). Notes on new or rare British fungi. (Trans. Brit. Myc. Soc. 7:79-85.)

DESCRIPTION OF PLATES

PLATE I

Fig. 1. *Hypoderma robustum* v. Tubeuf on *Abies concolor.* Note the linear hysterothecia along the midribs of many of the two year old needles (x 0.5).

Fig. 2. *Hypodermella Abietis-concoloris* (Mayr) Dearness on *Abies concolor.* The hysterothecia occur along the midribs of the two year old needles (x 0.5).

Fig. 3. *Lophodermium Piceae* (Fuckel) v. Höhnel on *Abies balsamea.* In this specimen the terminal bud has failed to develop for several years. The diseased needles bear numerous pycnidia and a few hysterothecia (x 1.3).

Fig. 4. *Hypodermella montana,* sp. nov., on *Pinus contorta.* The hysterothecia occur on sordid areas on two year old needles (x 0.5).

Fig. 5. *Hypodermella concolor* (Dearness), comb. nov., on *Pinus Banksiana.* This twig was artificially infected one year before the photograph was taken (x 0.7).

PLATE II

Fig. 1–12. Diagrams of the pycnidial fructifications of the "nervisequious" species of Hypodermataceae on Abies.

1. *Hypodermella lirelliformis,* sp. nov., on *Abies alba.* Thümen, Myc. univ. 463. No evidence of pycnidia.
2. *H. lirelliformis* on *A. alba.* Fuckel, Fungi rhen. 2559. A single row of colorless punctiform pycnidia.
3. *H. lirelliformis* on *A. alba.* Linhart, Fungi hung. 65. A single, continuous pycnidium.
4. *Bifusella Faullii,* sp. nov., on *Abies balsamea.* An effused or labyrinthine pycnidium.
5. *Bifusella Abietis* Dearness on *Abies lasiocarpa.* A double row of colorless pycnidia.
6. *Hypodermella mirabilis,* sp. nov., on *A. balsamea.* A double row of colorless pycnidia, rarely fused along the midrib.

7. *Hypoderma robustum* v. Tubeuf on *Abies concolor.* A double row of colorless pycnidia.
8. *H. robustum* on *A. concolor.* Pycnidia somewhat labyrinthine.
9. *Hypodermella punctata,* sp. nov., on *A. concolor.* Pycnidia brown, punctiform.
10. *Hypodermella Abietis-concoloris* (Mayr) Dearness on *A. concolor.* Pycnidium dark brown before pycnidial discharge.
11. *Hypodermella nervata,* sp. nov., on *A. balsamea.* Pycnidium at first concolorous with leaf surface, later becoming dark colored.
12. *Hypodermella nervisequia* (Fr.) Lag. on *A. alba.* Pycnidia broad, dark brown.

PLATE III

Fig. 1–4. *Bifusella linearis* (Peck) v. Höhnel on *Pinus Strobus.*

1. Hysterothecium at maturity (x 17).
2. Ascus (x 500).
3. Ascospores from dried herbarium material (x 500).
4. Ascospores from fresh material, showing germination in distilled water (x 500).

Fig. 5–9. *Bifusella Abietis* Dearness on *Abies lasiocarpa.*

5. Needle with double row of concolorous pycnidia on its upper surface (x 3 approx.).
6. Portion of hysterothecium on lower surface of needle. Note the band of light colored pseudoparenchyma along which the hysterothecium ruptures (x 17).
7. Ascus and paraphysis at maturity (x 500).
8–9. Ascospores from dry herbarium material (x 500).

Fig. 10–11. *Bifusella Faullii,* sp. nov., on *Abies balsamea.*

10. Portion of a hysterothecium (x 17).
11. Needle showing the linear hysterothecium (x 5 approx.).

PLATE IV

Fig. 1–5. *Bifusella Faullii,* sp. nov., on *Abies balsamea.*

1. Portion of pycnidium on upper surface of needle. Note the conidial tendrils produced in moist chamber (x 17).
2. Ascus and paraphyses (x 500).
3. Ascospores showing different stages of germination in distilled water. The production of flat, expanded appressoria is typical of this species (x 500).
4. Ascospores germinating in turnip extract (x 500).

5. Conidia (x 2000).

Fig. 6–7. *Bifusella crepidiformis,* sp. nov., on *Picea mariana.*

6. Needle with hysterothecia (x 5 approx.).

7. Hysterothecia on portions of needles (x 17).

PLATE V

Fig. 1–4. *Bifusella crepidiformis,* sp. nov., on *Picea mariana.*

1. Ascus and paraphysis slightly immature (x 500).

2. Ascospores germinating in distilled water (x 500).

3. Two ascospores germinating on surface of agar (x 500).

4. Ascospore germinating under layer of agar, showing two stages in the germination of the same spore (x 500).

Fig. 5. *Bifusella crepidiformis,* sp. nov., on *Picea glauca.* Mature ascus and paraphysis (x 500).

PLATE VI

Fig. 1–2. *Bifusella crepidiformis,* sp. nov., on *Picea glauca.*

1. Ascospores germinating in distilled water (x 500).

2. Ascospores obtained from hysterothecia kept for about three days in a moist chamber (x 500).

Fig. 3–5. *Bifusella striiformis,* sp. nov., on *Pinus Pinaster.*

3. Portion of needle with numerous narrow hysterothecia opening along the stomatal lines (x 17).

4. Ascus and paraphyses (x 500).

5. Ascospores from fresh material, in distilled water, showing one spore germinating (x 500).

Fig. 6. *Bifusella striiformis,* sp. nov., on *Pinus Torreyana.* Ascospores, from fresh material, showing germination in distilled water. Note the variation in shape and size of the spores (x 500).

PLATE VII

Fig. 1–4. *Hypoderma Desmazierii* Duby on *Pinus Strobus.*

1. Portion of needle with hysterothecia (x 17).

2. Ascus and paraphyses (x 500).

3. Mature ascospores in various stages of germination in distilled water (x 500).

4. Ascospore germinating on agar (x 500).

Fig. 5. *Hypoderma Desmazierii* Duby on *Pinus resinosa.* Ascospores in various stages of germination in distilled water (x 500).

Fig. 6. *Hypoderma robustum* v. Tubeuf on *Abies concolor.* Portion of hysterothecium showing the band of light colored plectenchyma along the middle of the fructification (x 17).

Fig. 7–8. *Hypoderma robustum* v. Tubeuf on *Abies amabilis.*
7. Ascus and paraphyses from dried material (x 500).
8. Ascospores showing germination in distilled water (x 500).

PLATE VIII

Fig. 1–3. *Hypoderma pedatum,* sp. nov., on *Pinus radiata.*
1. Portion of needle with hysterothecia (x 17).
2. Ascus and paraphysis (x 500).
3. Ascospores germinating in distilled water (x 500).
Fig. 4–6. *Hypoderma lethale* Dearness on *Pinus rigida.*
4. Portion of needle with hysterothecia (x 17).
5. Ascus and paraphysis (x 500).
6. Ascospores from dry herbarium material (x 500).
Fig. 7–9. *Hypoderma Hedgcockii* Dearness on *Pinus caribaea.*
7. Portion of needle with hysterothecia (x 17).
8. Ascus and paraphyses. Note the aborted spores (x 500).
9. Aborted and mature spores (x 500).

PLATE IX

Fig. 1–3. *Hypoderma saccatum,* sp. nov., on *Pinus edulis.*
1. Portion of needle with pycnidium (x 17).
2. Portion of needle with hysterothecium (x 17).
3. Ascus and paraphyses (x 500).
Fig. 4–7. *Hypoderma Pini* (Dearness), sp. nov., on *Pinus monophylla.*
4. Needle with black hysterothecia and light colored pycnidia (x 4).
5. Ascus at maturity (x 500).
6. Ascospores from dried material showing one spore which had germinated within the ascus (x 500).
7. Ascospores discharged from asci and caught on cover glasses (x 500). Note the aborted spores. The spore in the lower right hand corner is a typical normal spore.

PLATE X

Fig. 1–6. *Hypodermella Laricis* v. Tubeuf on *Larix laricina.*
1. Portion of needle with hysterothecia (x 17).
2. Immature ascus and paraphysis (x 500).
3. Ascus and paraphyses almost mature (x 500).
4. Immature ascospores (x 500).
5. Mature ascospores germinating in distilled water (x 500).
6. Conidia (x 2000).

Fig. 7–8. *Hypodermella limitata,* sp. nov., on *Pinus radiata.*

7. Hysterothecia on brown area on living needle (x 17).

8. Ascus and paraphysis (x 500). Note the aborted spores.

Fig. 9–10. *Hypodermella lacrimiformis,* sp. nov., on *Pinus attenuata.*

9. Ascus and paraphyses (x 500).

10. Ascospores in early stages of germination in distilled water (x 500).

PLATE XI

Fig. 1–3. *Hypodermella medusa* Dearness on *Pinus Jeffreyi.*

1. Hysterothecia on portion of needle (x 17).

2. Ascus and paraphysis (x 500).

3. Ascospores from dried herbarium material (x 500).

Fig. 4–9. *Hypodermella ampla* (Davis) Dearness on *Pinus Banksiana.*

4. Hysterothecia on whitened portion of needle (x 5 approx.).

5. Confluent hysterothecia (x 17).

6. Ascus and paraphyses (x 500).

7. A group of three ascospores from dried herbarium material (x 500).

8. Ascospores germinating in distilled water (x 500).

9. Ascospore germinating on agar (x 500).

PLATE XII

Fig. 1–2. *Hypodermella montana,* sp. nov., on *Pinus contorta.*

1. Ascus and paraphysis (x 500).

2. Ascospores at maturity in distilled water, the spore on the right beginning to germinate (x 500).

Fig. 3. *Hypodermella lirelliformis,* sp. nov., on *Abies alba.* Note the scattered pycnidia concolorous with the leaf surface (x 7 approx.).

Fig. 4–9. *Hypodermella mirabilis,* sp. nov., on *Abies balsamea.*

4. Needle with pycnidia (x 5 approx.).

5. Ascus slightly immature (x 500).

6. Ascus at maturity (x 500).

7. A group of eight ascospores showing different stages of germination in distilled water (x 500). (Compare with germination of *Bifusella Faullii*).

8. Conidia (x 2000).

PLATE XIII

Fig. 1. *Hypodermella mirabilis,* sp. nov., on *Abies balsamea.* Ascospores germinating in distilled water (x 500).

Fig. 2. *Hypodermella punctata,* sp. nov., on *Abies concolor.* Note the small punctiform pycnidia (x 8).

Fig. 3–4. *Hypodermella punctata,* sp. nov., on *Abies nobilis.*

3. A portion of a needle with linear, interrupted hysterothecium (x 17).

4. Ascus and paraphysis. Note the aborted spores (x 500).

Fig. 5–7. *Hypodermella Abietis-concoloris* (Mayr) Dearness on *Abies concolor.*

5. Ascus and paraphysis from dried material (x 500).

6. Ascospores from dried herbarium material (x 500).

7. Ascospores from fresh material germinating in distilled water (x 500).

PLATE XIV

Fig. 1–8. *Hypodermella nervata,* sp. nov., on *Abies balsamea.*

1. Needle with pycnidia (x 5 approx.).

2. Lower surface of same needle showing the hysterothecium (x 5 approx.).

3. Another needle with open hysterothecium (x 5 approx.).

4. Portion of needle with open hysterothecium (x 17).

5. Portions of needles showing pycnidia. The specimen on the left is typical of the species (x 17).

6. Ascus and paraphyses at maturity (x 500).

7. Ascospores from dried herbarium material (x 500).

8. Ascospores germinating in distilled water (x 500).

PLATE XV

Fig. 1–2. *Hypodermella nervata,* sp. nov., on *Abies balsamea.*

1. Ascospores germinating in distilled water (x 500).

2. Conidia (x 2000).

Fig. 3. *Hypodermella sulcigena* (Rostrup) v. Tubeuf on *Pinus sylvestris.* Ascus and paraphysis (x 500).

Fig. 4–6. *Hypodermella montivaga* (Petrak) Dearness on *Pinus contorta.*

4. Ascus and paraphyses (x 500).

5. Ascospores from dried material (x 500).

6. Ascospores germinating in distilled water (x 500).

Fig. 7–9. *Hypodermella arcuata,* sp. nov., on *Pinus Lambertiana.*

7. Portion of needle with hysterothecia (x 17).

8. Ascus and paraphysis (x 500).

9. Ascospores from dried material (x 500).

PLATE XVI

Fig. 1–4. *Hypodermella concolor* (Dearness), sp. nov., on *Pinus Banksiana.*

1. Portion of needle with hysterothecia (x 17).
2. Ascus and paraphysis (x 500).
3. Ascospores in different stages of germination in distilled water (x 500).
4. Tips of paraphyses showing types found in old, overmature hysterothecia (x 500).

Fig. 5. *Hypodermella conjuncta,* sp. nov., on *Pinus sylvestris.* Ascus and paraphysis slightly immature (x 500).

Fig. 6–7. *Hypodermella cerina,* sp. nov., on *Pinus contorta.*
6. Ascus and paraphyses (x 500).
7. Ascospore (x 500).

Fig. 8–10. *Elytroderma deformans* (Weir), comb. nov., on *Pinus Banksiana.*
8. Portion of needle with hysterothecia (x 17).
9. Ascus and paraphyses (x 500).
10. Ascospores (x 500).

PLATE XVII

Fig. 1–5. *Lophodermium juniperinum* (Fries) de Notaris on *Juniperus communis* var. *depressa.*
1. Needle with hysterothecia (x 8).
2. Portion of needle with hysterothecia enlarged (x 17).
3. Ascus and paraphyses (x 500).
4. Mature ascospores (x 500).
5. Ascospores germinating in distilled water (x 500).

Fig. 6–7. *Lophodermium juniperinum* (Fries) de Notaris on *Libocedrus decurrens.*
6. Portions of twigs with hysterothecia (x 7 approx.).
7. Ascospore (x 500).

Fig. 8–10. *Lophodermium cedrinum* Maire on *Cedrus atlantica.*
8. Needle with hysterothecia (x 8).
9. Ascus and paraphysis (x 500).
10. Asci in cross sectional view (slightly crushed) (x 500).

Fig. 11. *Lophodermium pinastri* (Schrader ex Fries) Chevallier on *Pinus attenuata.* Ascospores germinating in distilled water (x 500).

Fig. 12–14. *Lophodermium pinastri* (Schrad. ex. Fr.) Chev. on *Pinus Banksiana.*
12. Needle with hysterothecia (x 3 approx.).
13. Portion of needle with hysterothecium (x 17).
14. Ascus and paraphysis (x 500).

PLATE XVIII

Fig. 1–4. *Lophodermium pinastri* (Schrad. ex. Fr.) Chev. on *Pinus Banksiana.*

1. Ascus and paraphyses at maturity (x 500).
2–3. Ascospores in various stages of germination in distilled water (x 500).
4. Conidia (x 2000).

Fig. 5–9. *Lophodermium pinastri* (Schrad. ex Fr.) Chev. on *Pinus contorta* var. *latifolia.*

5. Portion of needle with hysterothecia (x 5 approx.).
6. Portion of needle with closed hysterothecium and pycnidium (x 17).
7. Portion of needle with open hysterothecium (x 17).
8. Ascus and paraphysis (x 500).
9. Ascospores germinating in distilled water (x 500).

PLATE XIX

Fig. 1. *Lophodermium pinastri* (Schrad. ex Fr.) Chev. on *Pinus nigra* var. *austriaca.* Ascospores germinating in distilled water (x 500).

Fig. 2. *Lophodermium pinastri* (Schrad. ex. Fr.) Chev. on *Pinus parviflora.* Ascospores germinating in distilled water (x 500).

Fig. 3–7. *Lophodermium pinastri* (Schrad. ex Fr.) Chev. on *Pinus resinosa.*

3. Portion of needle with hysterothecium (x 17).
4. Ascus and paraphyses at maturity (x 500).
5. Ascospore (x 500).
6. Ascospores germinating in distilled water (x 500).
7. Conidia (x 2000).

PLATE XX

Fig. 1. *Lophodermium pinastri* (Schrad. ex Fr.) Chev. on *Pinus rigida.* Ascospores germinating in distilled water (x 500).

Fig. 2–3. *Lophodermium pinastri* (Schrad. ex Fr.) Chev. on *Pinus Strobus.*

2. Hysterothecium closed (x 17).
3. Hysterothecium open (x 17).

Fig. 4–9. *Lophodermium laricinum* Duby on *Larix laricina.*

4. Needle with hysterothecia (x 3 approx.).
5. Portion of needle with pycnidia (x 17).
6. Portion of needle with hysterothecium (x 17).
7. Ascus and paraphyses (x 500).

8. Ascospores germinating in distilled water (x 500).
9. Conidia (x 2000).

Fig. 10–15. *Lophodermium nitens,* sp. nov., on *Pinus Strobus.*

10. Portion of needle with pycnidia (x 17).
11. Portion of needle with closed hysterothecium (x 17).
12. Portion of needle with open hysterothecium (x 17).
13. Ascus and paraphyses (x 500).
14. Ascospores germinating in turnip extract (x 500).
15. Conidia (x 2000).

Fig. 16. *Lophodermium uncinatum,* sp. nov., on *Abies amabilis.* Ascus and paraphysis (x 500).

PLATE XXI

Fig. 1–5. *Lophodermium autumnale*, sp. nov., on *Abies balsamea.*

1. Needle with scattered hysterothecia and pycnidia on its upper surface (x 5 approx.).
2. Portion of needle enlarged showing confluent hysterothecium (x 17).
3. Ascus and paraphysis (x 500).
4. Ascospores in various stages of germination in distilled water (x 500).
5. Conidia (x 2000).

Fig. 6–9. *Lophodermium Thuyae* Davis on *Thuja occidentalis.*

6. Portion of twig with hysterothecia (x 7 approx.).
7. Needle with hysterothecium (x 17).
8. Ascus and paraphyses (x 500).
9. Ascospores germinating in distilled water (x 500).

Fig. 10. *Lophodermium consociatum,* sp. nov., on *Abies amabilis.* Ascus and paraphysis (x 500).

PLATE XXII

Fig. 1–6. *Lophodermium lacerum,* sp. nov., on *Abies balsamea.*

1. Needle with hysterothecia on the lower surface (x 3 approx.).
2–3. Portions of needles showing mature hysterothecia (x 17).
4. Asci (x 500).
5. Ascospores germinating in distilled water (x 500).
6. Conidia (x 2000).

PLATE XXIII

Fig. 1–5. *Lophodermium Piceae* (Fuckel) v. Höhnel on *Abies balsamea.*

1. Hysterothecia and pycnidia on portion of a needle (x 17).

2. Ascus and paraphyses (x 500).
3. Mature ascospore (x 500).
4. Germinating ascospores, the four upper spores in distilled water, the two lower on surface of agar (x 500).
5. Conidia (x 2000).

Fig. 6–11. *Lophodermium Piceae* (Fuckel) v. Höhnel on *Picea Abies.*

6. Needle with hysterothecia and pycnidia (x 7 approx.).
7. Portion of needle with an open hysterothecium (x 17).
8. Mature asci and paraphyses (x 500).
9. Ascospore (x 500).
10. Germinating ascospores, the four upper in distilled water, the lower spore on the surface of malt agar (x 500).
11. Conidia (x 2000).

PLATE XXIV

Fig. 1–6. *Lophodermium Piceae* (Fuckel) v. Höhnel on *Picea glauca.*

1. Needle with hysterothecia and pycnidia (x 5 approx.).
2. Portion of needle with hysterothecia and pycnidia (x 17).
3. Portion of needle with open hysterothecia (x 17).
4. Ascus and paraphyses (x 500).
5. Germinating ascospores, the three on the left in distilled water, the three on the right on the surface of agar (x 500).
6. Conidia (x 2000).

Fig. 7–11. *Lophodermium Piceae* (Fuckel) v. Höhnel on *Picea mariana.*

7. Needle with hysterothecium and pycnidia (x 5 approx.).
8. Portion of needle with closed hysterothecium (x 17).
9. Portion of needle with open hysterothecium (x 17).
10. Ascus and paraphyses (x 500).
11. Ascospores showing germination in distilled water (x 500).

PLATE XXV

Fig. 1–3. *Lophodermium Piceae* (Fuckel) v. Höhnel on *Picea mariana.*

1. Ascospores germinating in distilled water (x 500).
2. Ascospores germinating under layer of agar (x 500). Note the sinuous appearance of the spores.
3. Conidia (x 2000).

Fig. 4. *Lophodermium macrosporum* (Hartig) Rehm on *Picea Abies.* Ascus and paraphysis (x 500).

Fig. 5–9. *Lophodermium filiforme,* sp. nov., on *Picea glauca.*
5. Needle with hysterothecia (x 7 approx.).
6. Portion of needle with hysterothecium (x 17).
7. Ascus and paraphyses slightly immature (x 500).
8. Ascospores germinating in distilled water (x 500).
9. Conidia (x 2000).

Fig. 10. *Lophodermium filiforme,* sp. nov., on *Picea mariana.* Ascospores germinating in distilled water (x 500).

PLATE XXVI

Fig. 1–3. *Lophodermium durilabrum,* sp. nov., on *Pinus monticola.*
1. Portion of needle with hysterothecia (x 17).
2. Ascus and paraphysis (x 500).
3. Asci in cross sectional view (x 500).

Fig. 4. *Lophodermium crassum,* sp. nov., on *Picea Breweriana.* Ascospores (x 500).

Fig. 5–7. *Lophodermium decorum,* sp. nov., on *Abies grandis.*
5. Portion of needle with hysterothecia (x 17).
6. Ascus and paraphysis (x 500).
7. Ascospore (x 500).

Fig. 8–9. *Naemacyclus niveus* (Persoon ex Fries) Saccardo on *Pinus ponderosa.*
8. Ascus and paraphyses slightly immature (x 500).
9. Ascospores germinating (x 500).

Fig. 10. *Naemacyclus niveus* (Persoon ex Fries) Saccardo on *Pinus radiata.* Mature ascospore (x 500).

Fig. 11. *Naevia piniperda* Rehm on *Picea glauca.* Ascus and paraphyses (x 500).

PLATE XXVII

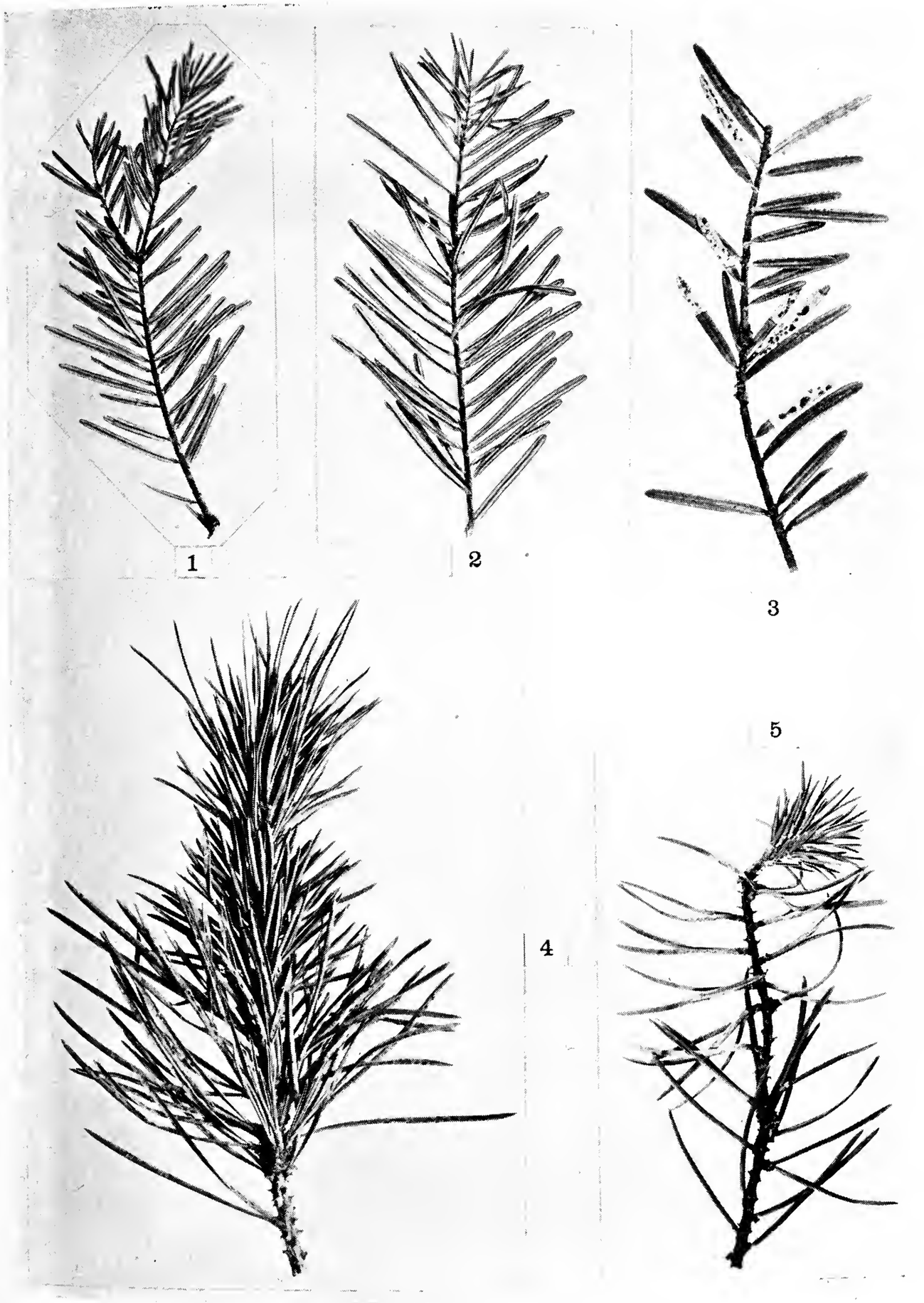
Fig. 1. *Elytroderma deformans* (Weir), comb. nov., on *Pinus Jeffreyi.* Cross section of pycnidium (x 333).

Fig. 2. *Lophodermium nitens,* sp. nov., on *Pinus Strobus.* Cross section of pycnidium (x 500).

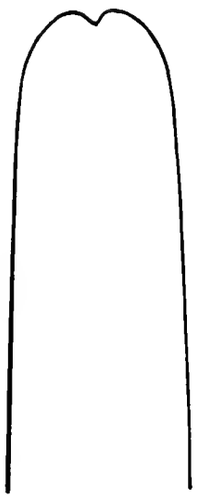
Fig. 3. *Bifusella striiformis,* sp. nov., on *Pinus Pinaster.* Cross section of hysterothecium (x 333).

INDEX

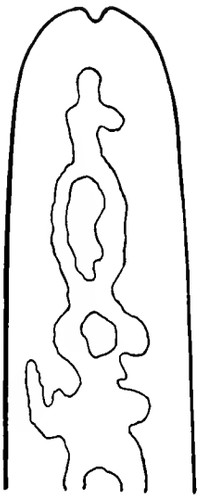
Synonyms are printed in *italics* and new names and new combinations in **bold-face** type



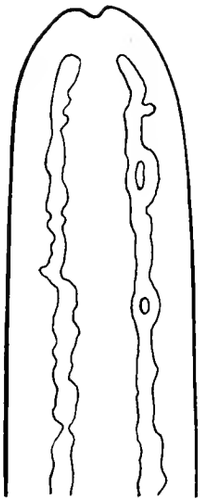
THE HYPODERMATACEAE OF CONIFERS.



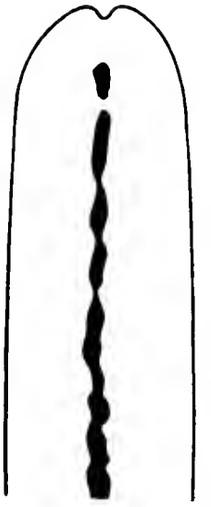
1



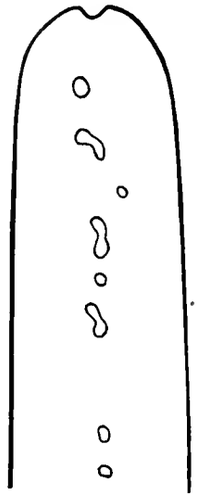
4



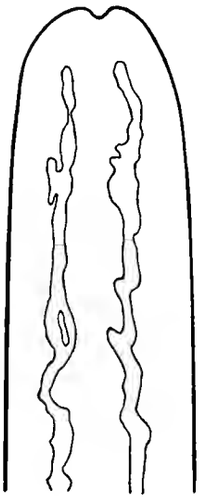
7



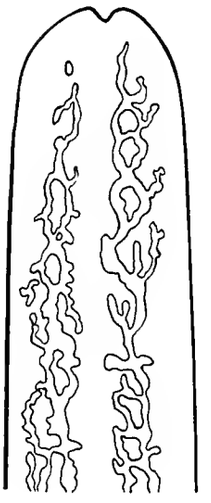
10



2

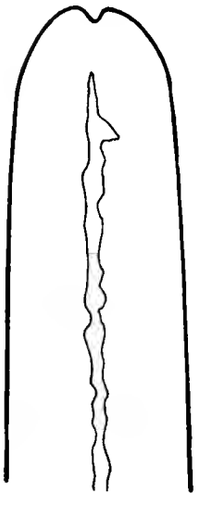


5

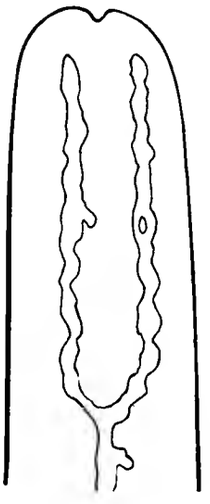


8

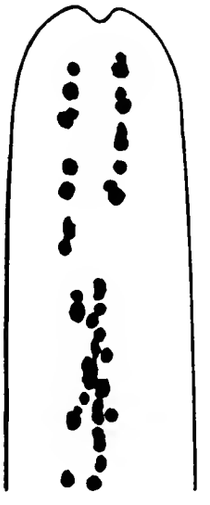
11



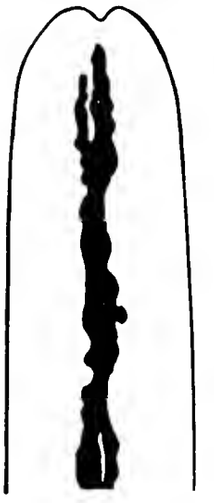
3



6



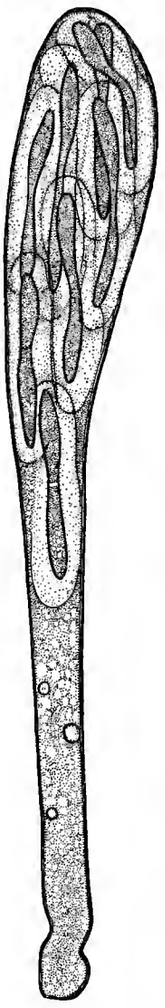
9



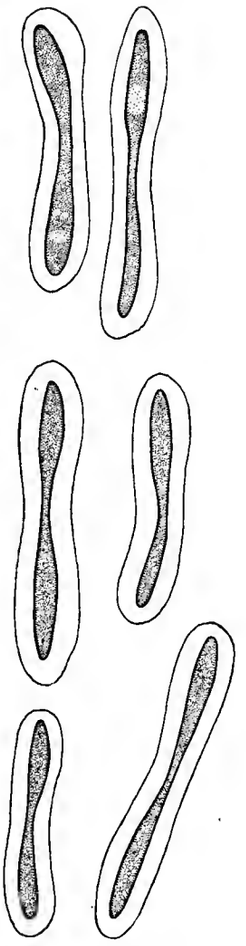
12

THE HYPODERMATACEAE OF CONIFERS.

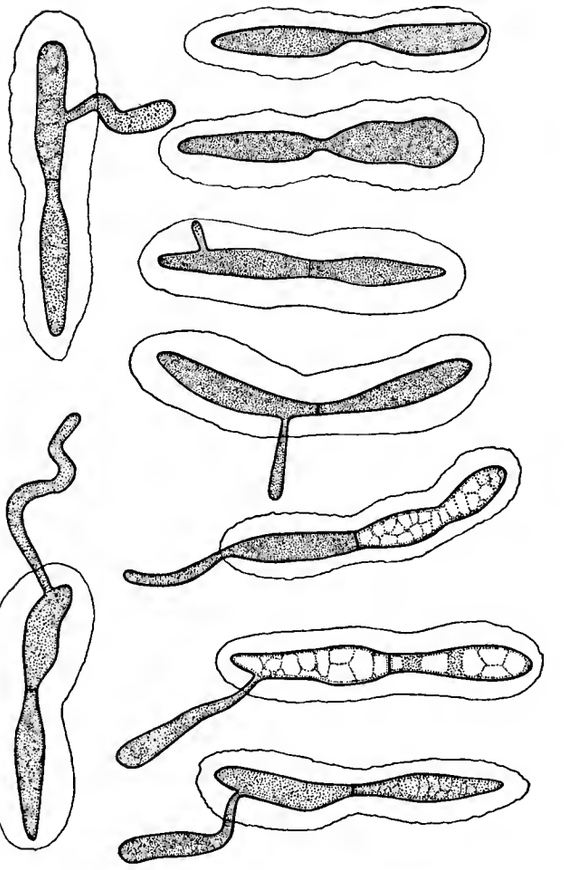
1



2



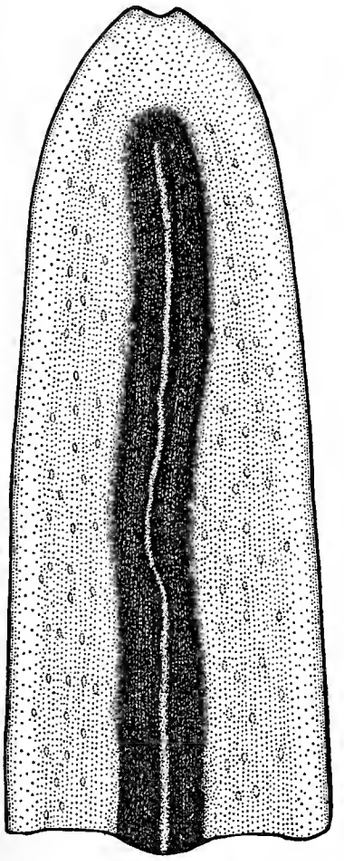
3



4

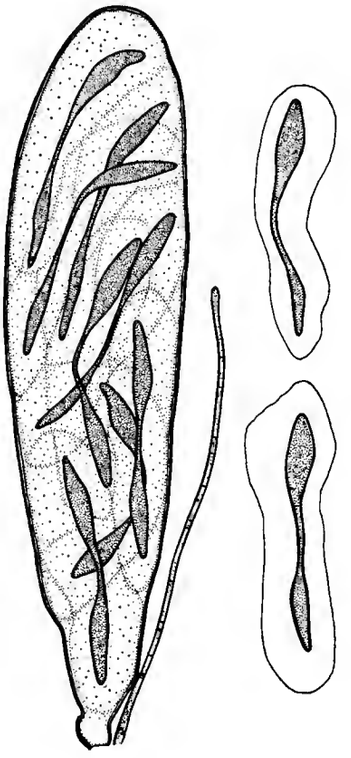
5

6



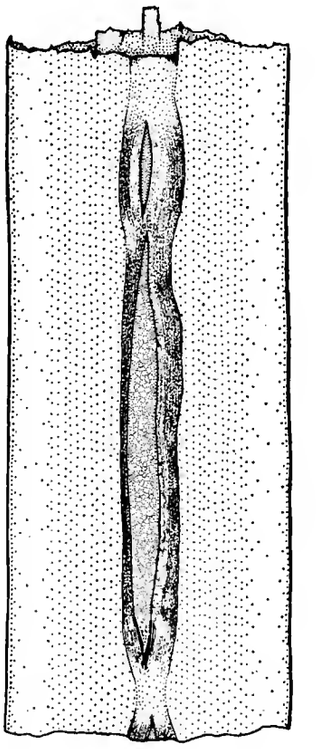
7

8



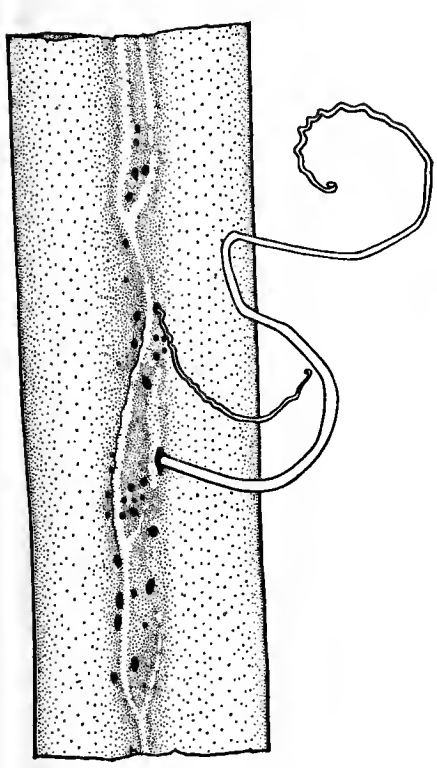
9

10

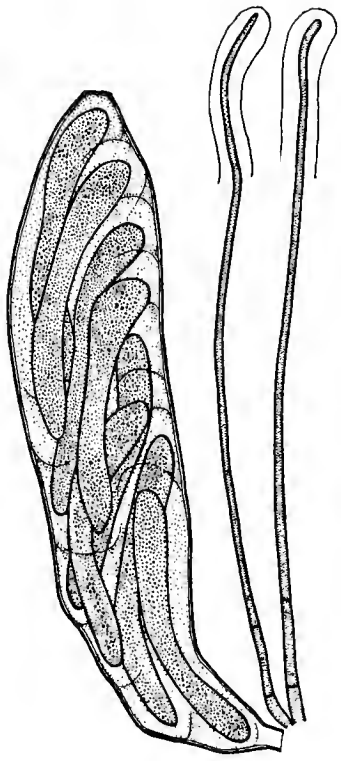


11

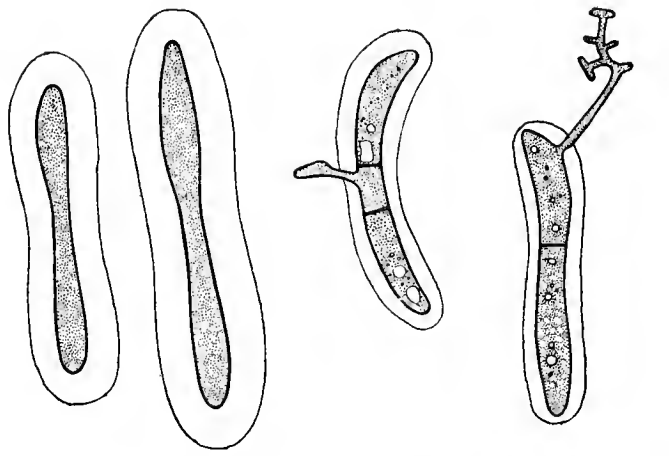
THE HYPODERMATACEAE OF CONIFERS.

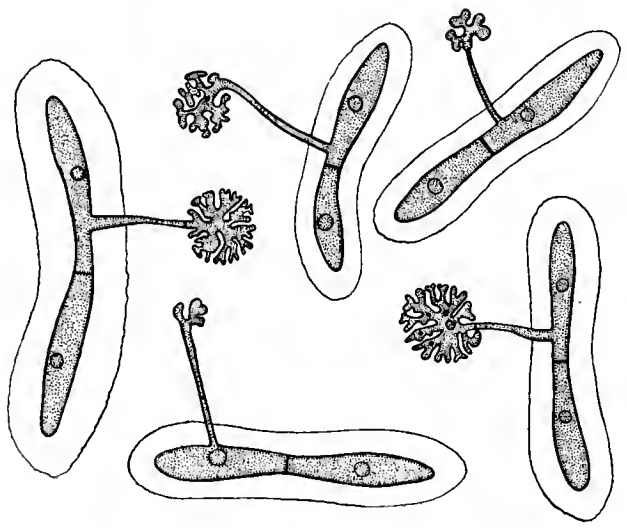


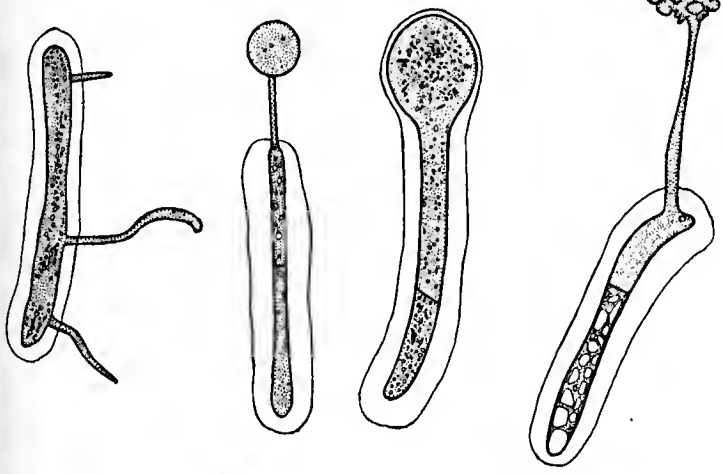
1

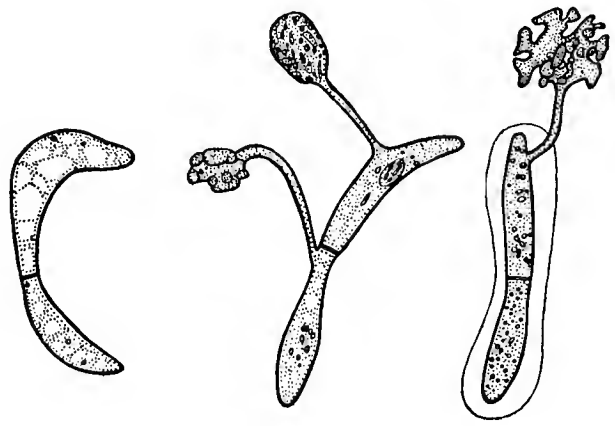


2

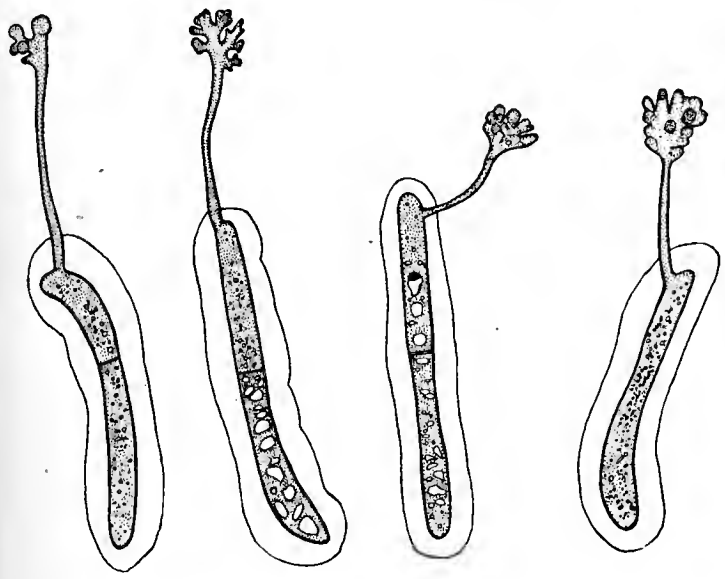








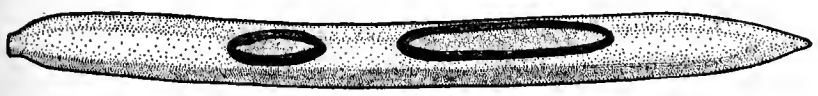
3

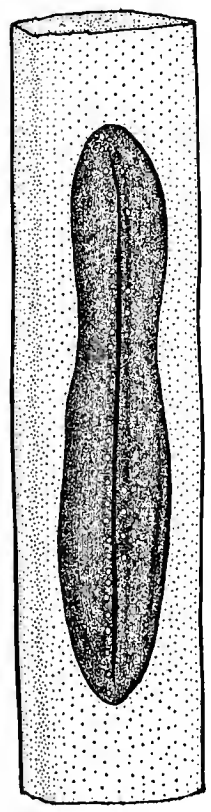


4

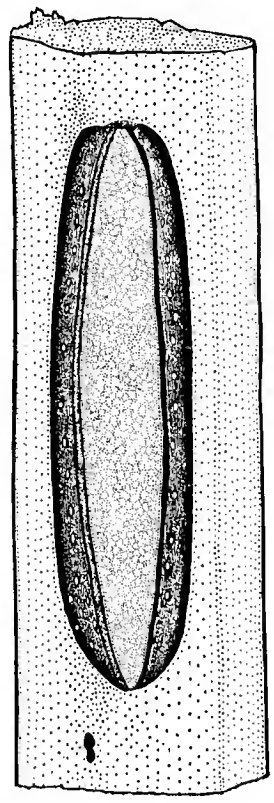
5

6

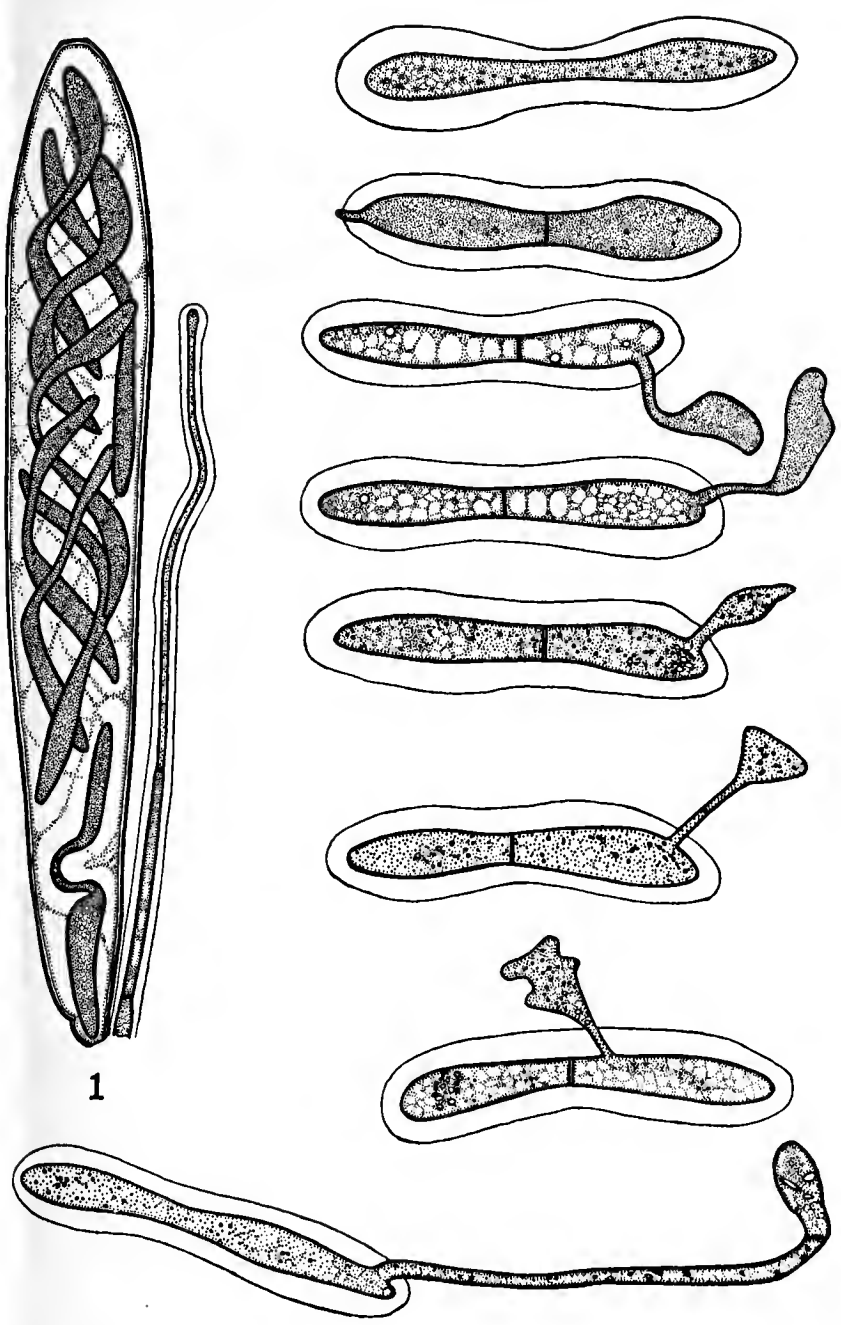




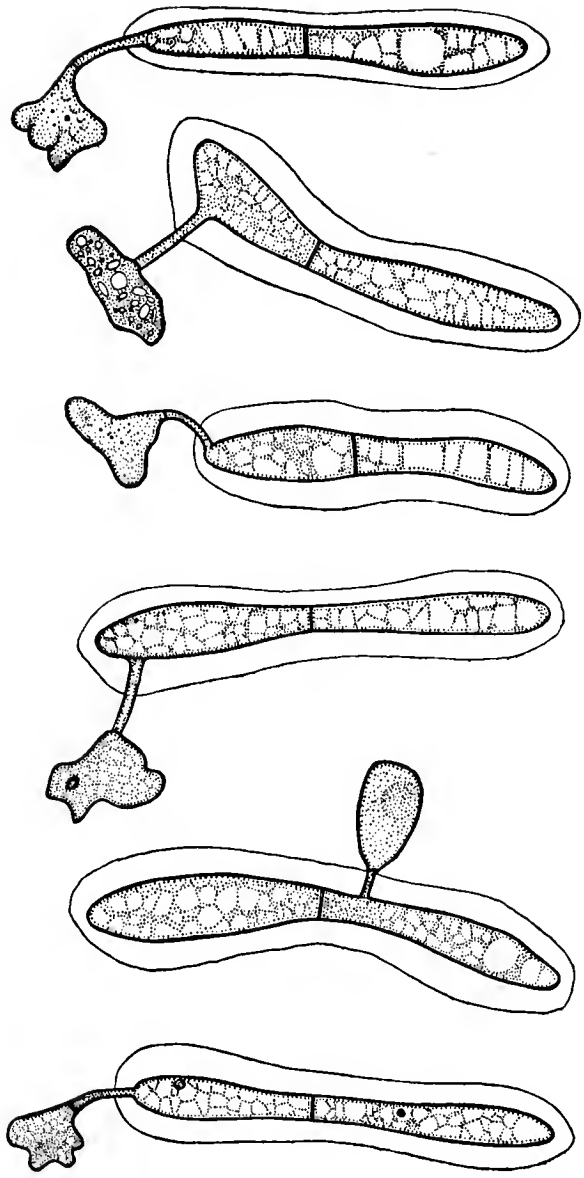
7



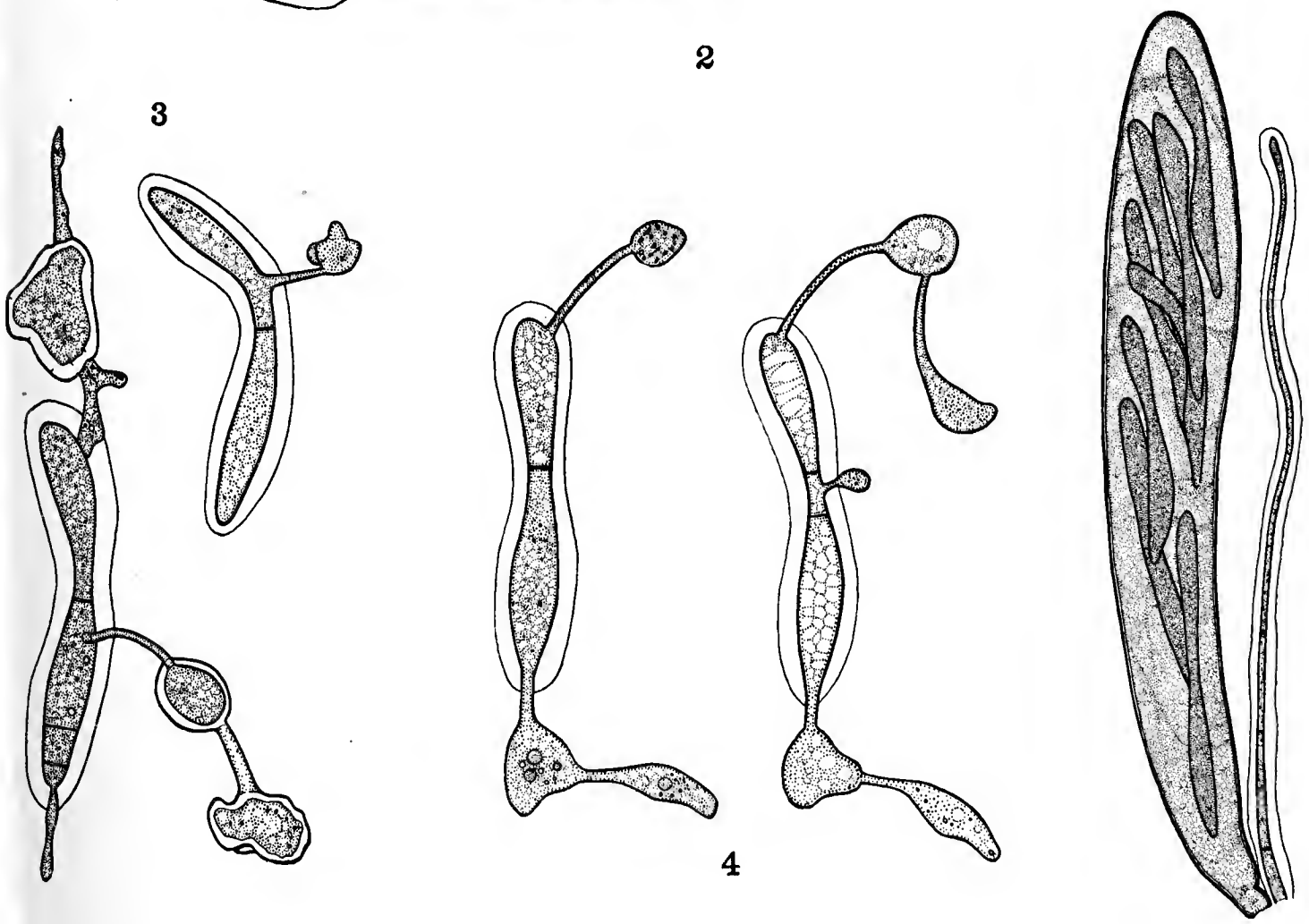
THE HYPODERMATACEAE OF CONIFERS.



1



5

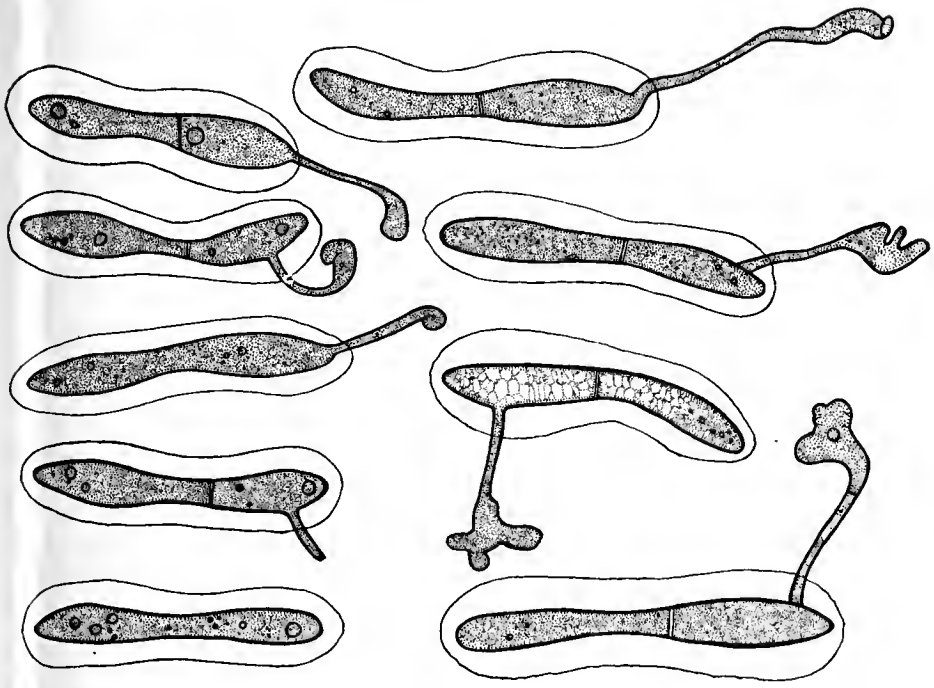


2

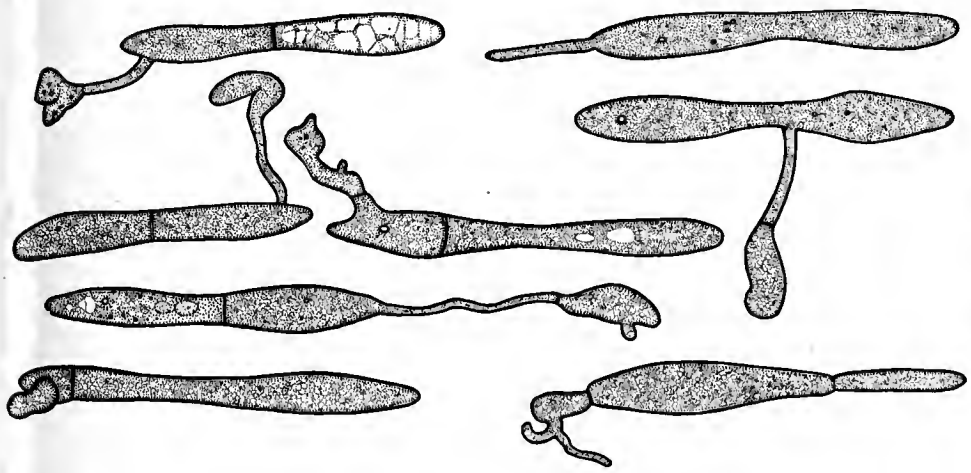
3

4

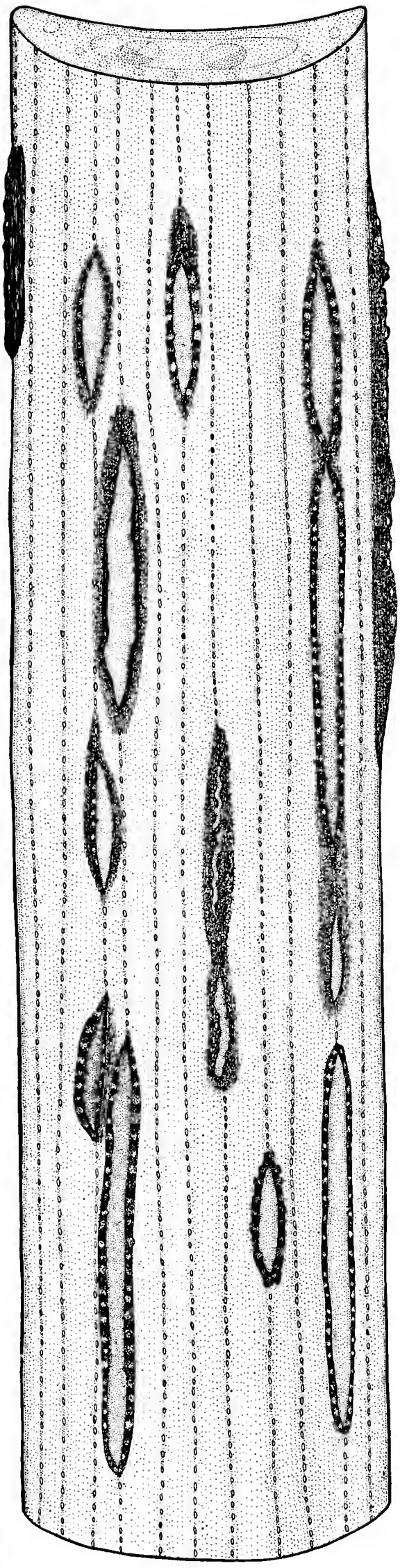
THE HYPODERMATACEAE OF CONIFERS.



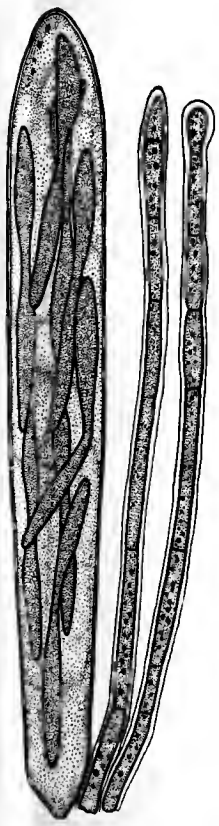
1



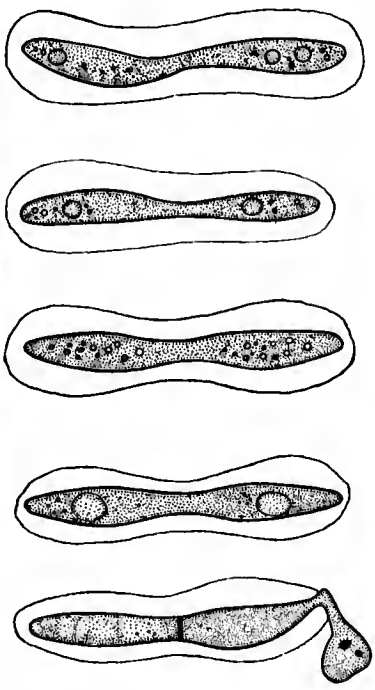
2



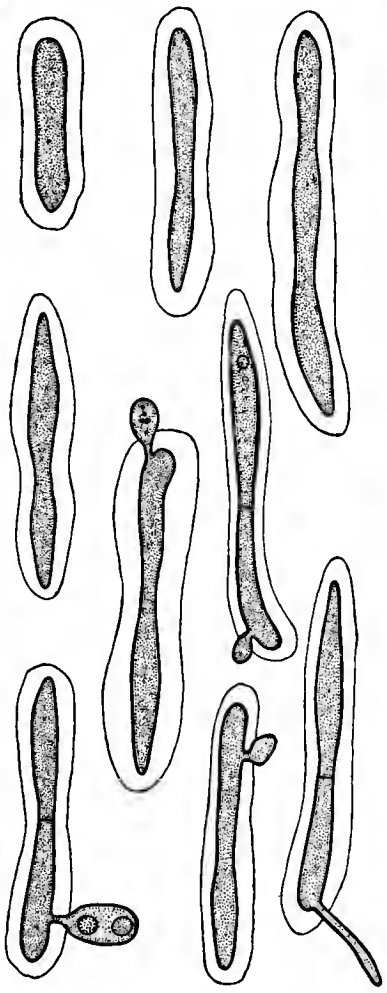
3



4

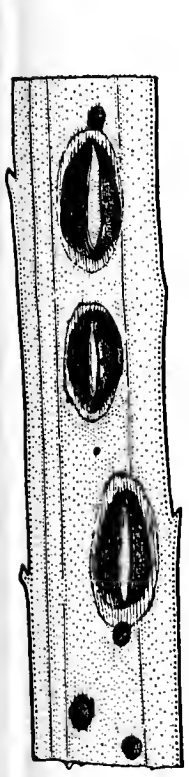


5

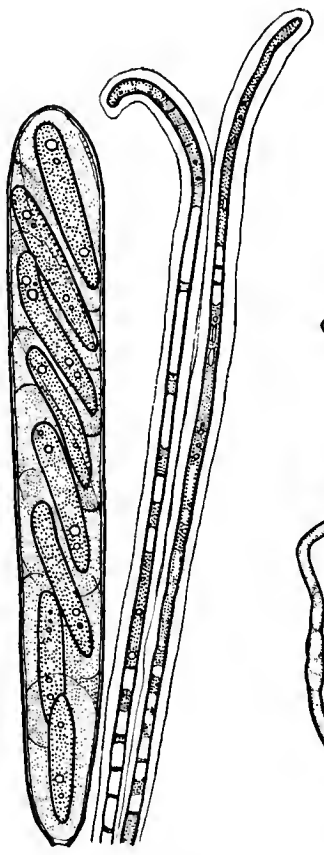


6

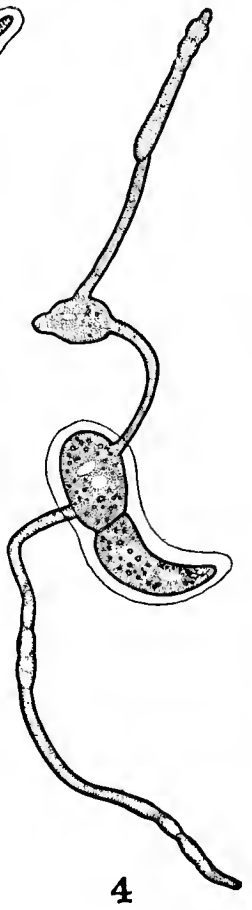
THE HYPODERMATACEAE OF CONIFERS.



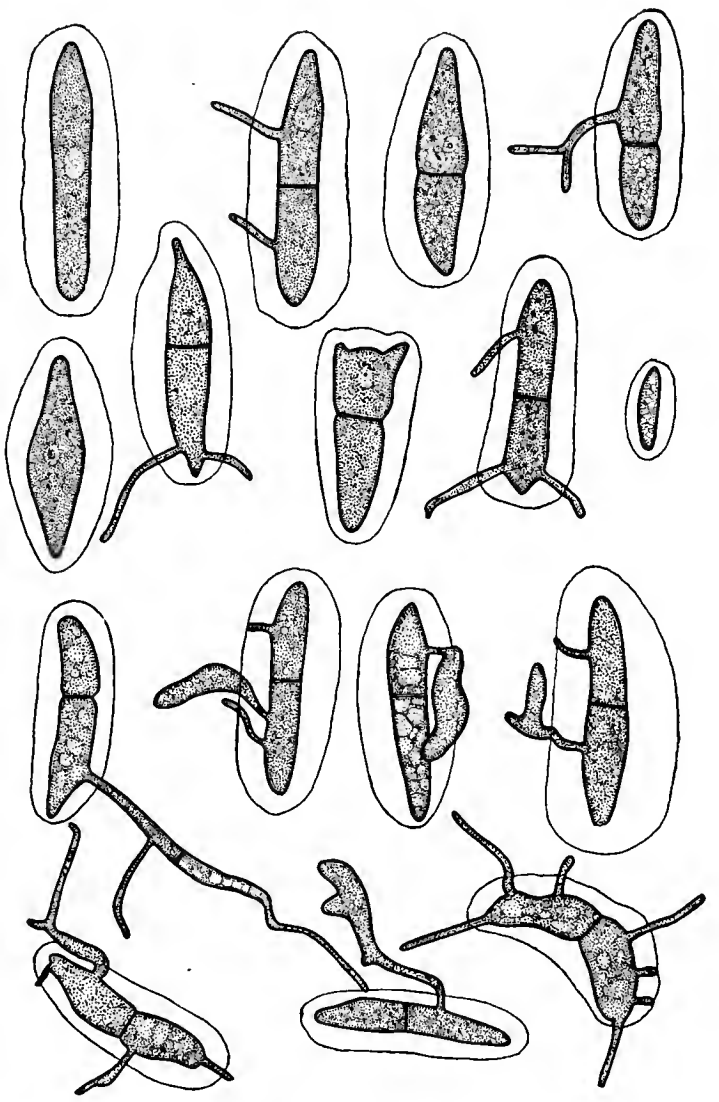
1



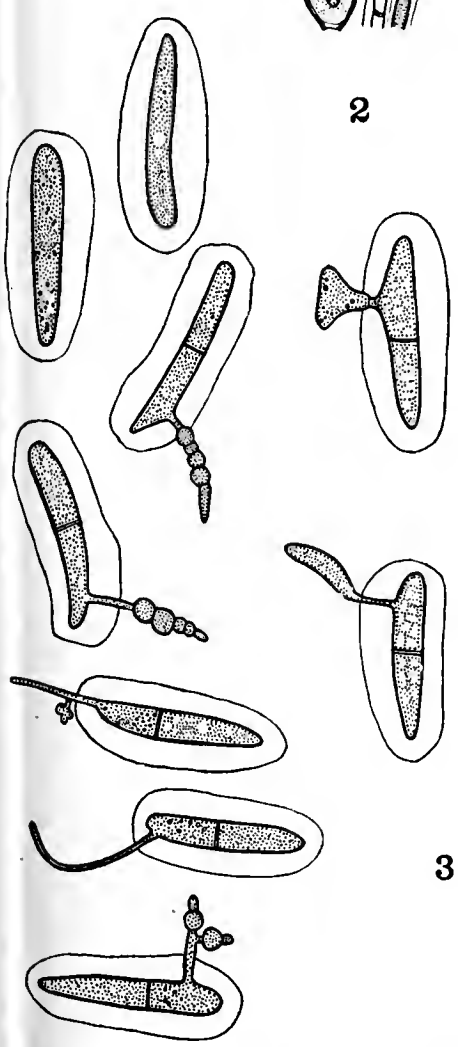
2



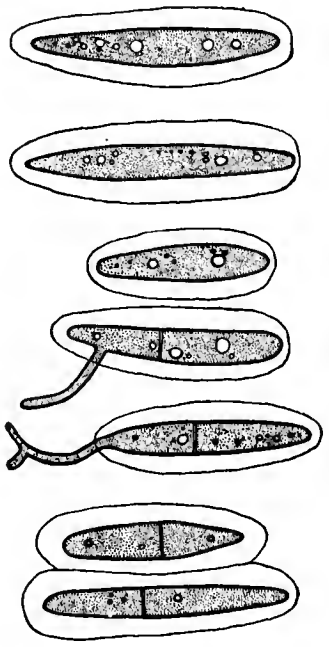
4

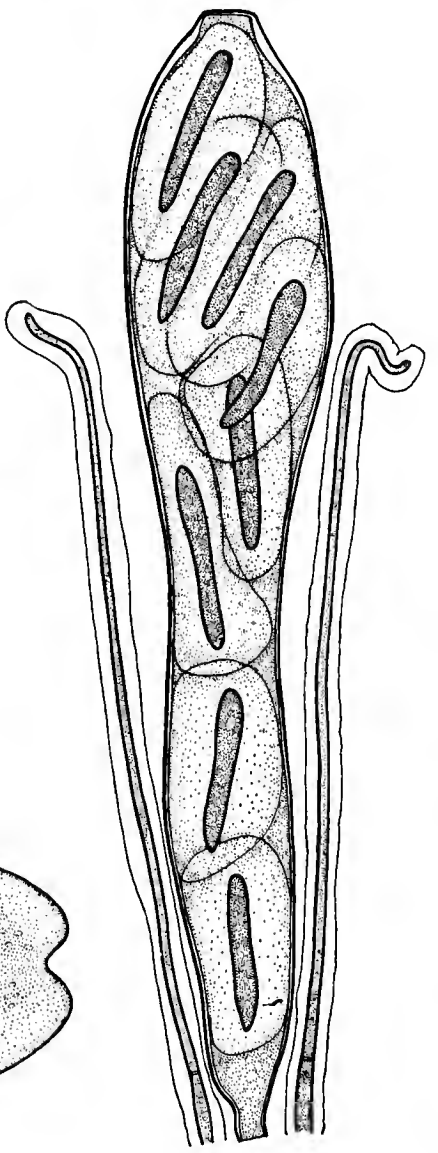


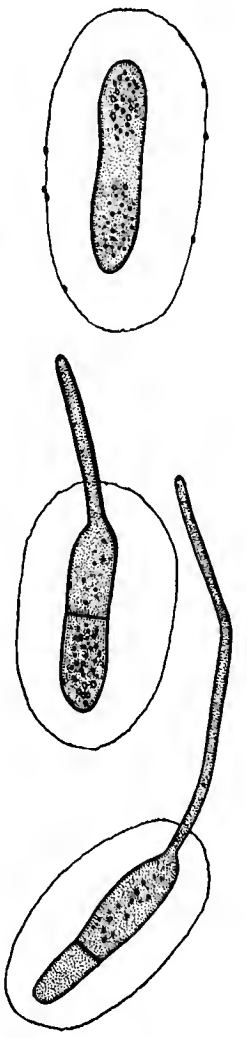
5

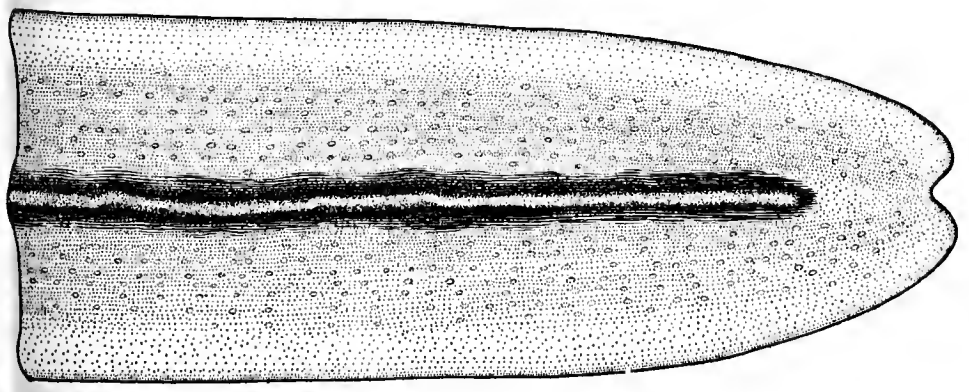


3



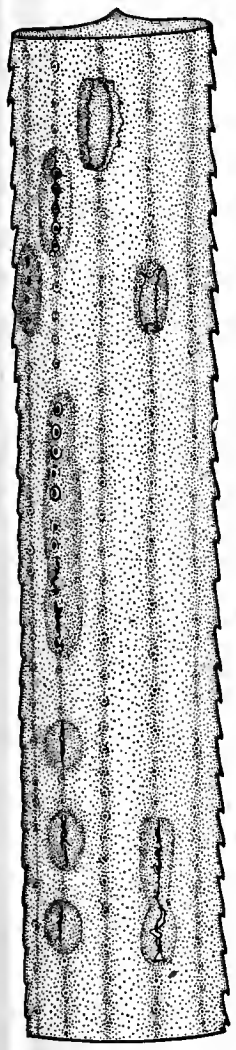




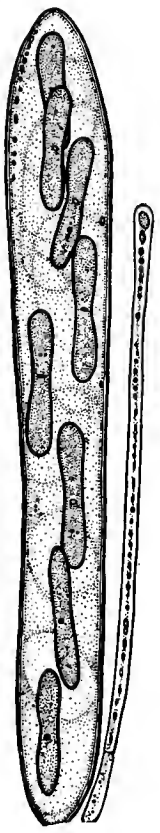


6 7 8

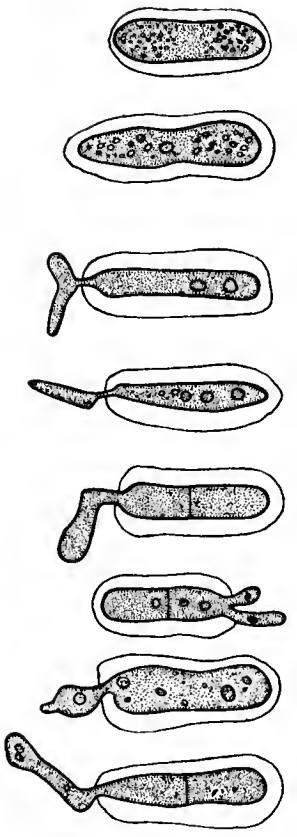
THE HYPODERMATACEAE OF CONIFERS.



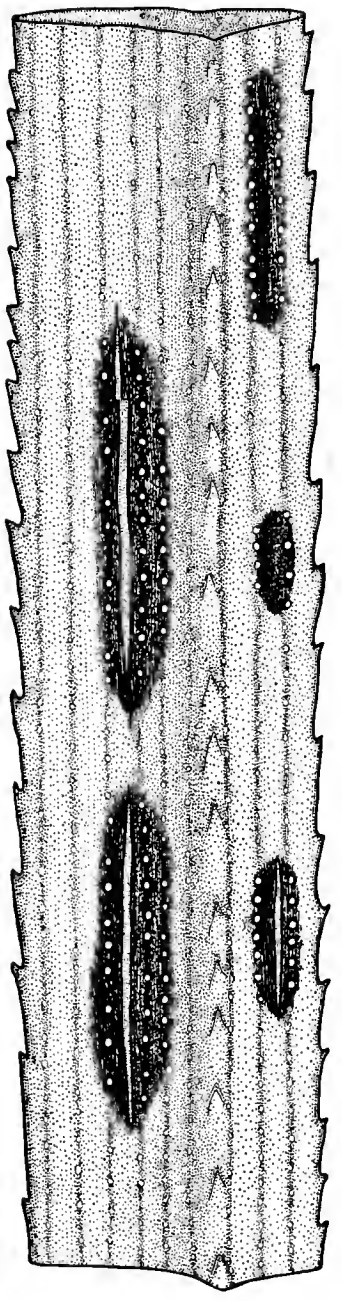
1



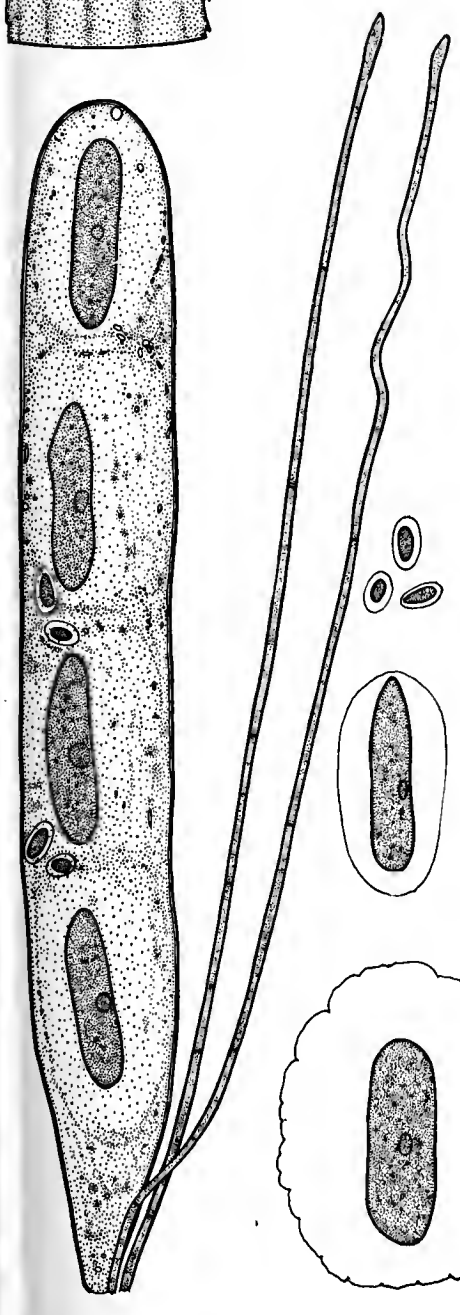
2

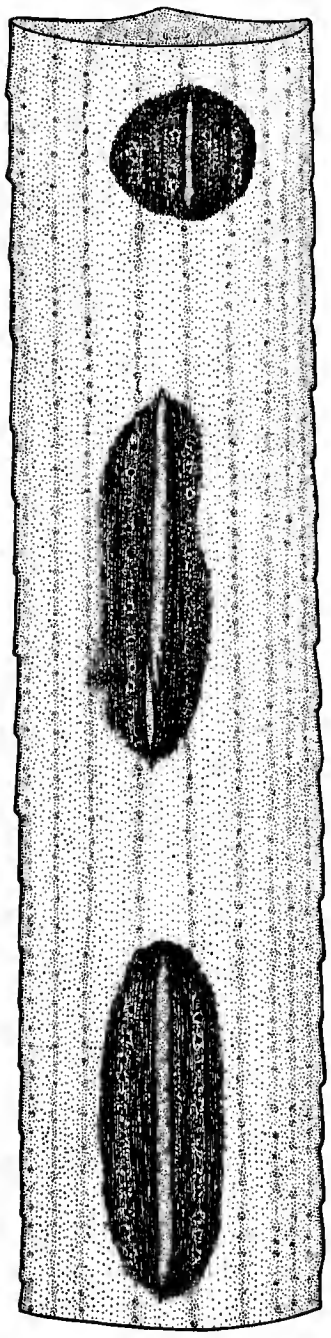


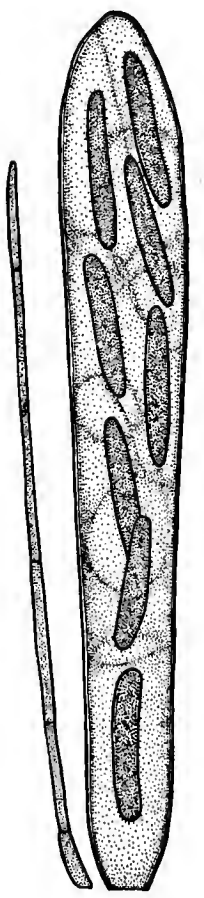
3



4



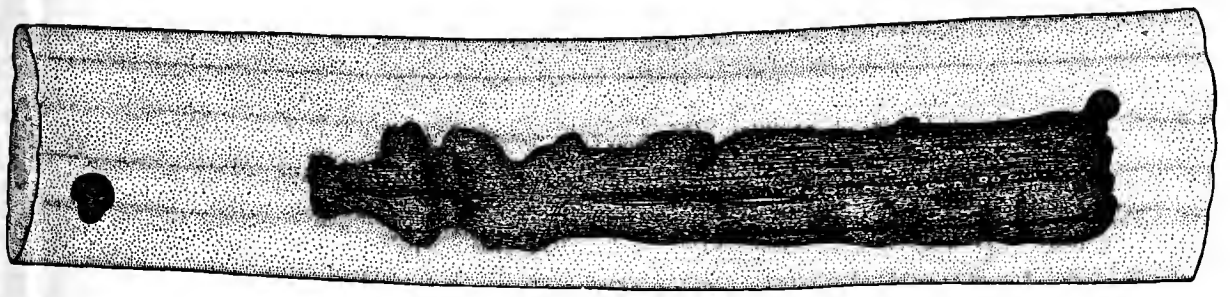




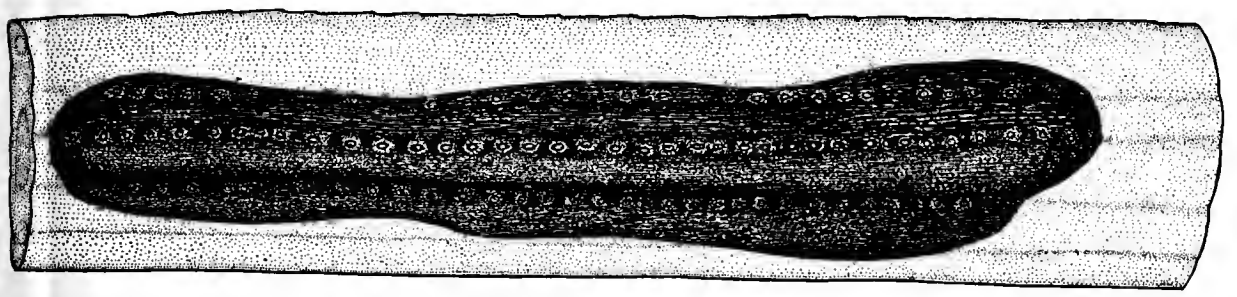
6

8 9 7 5

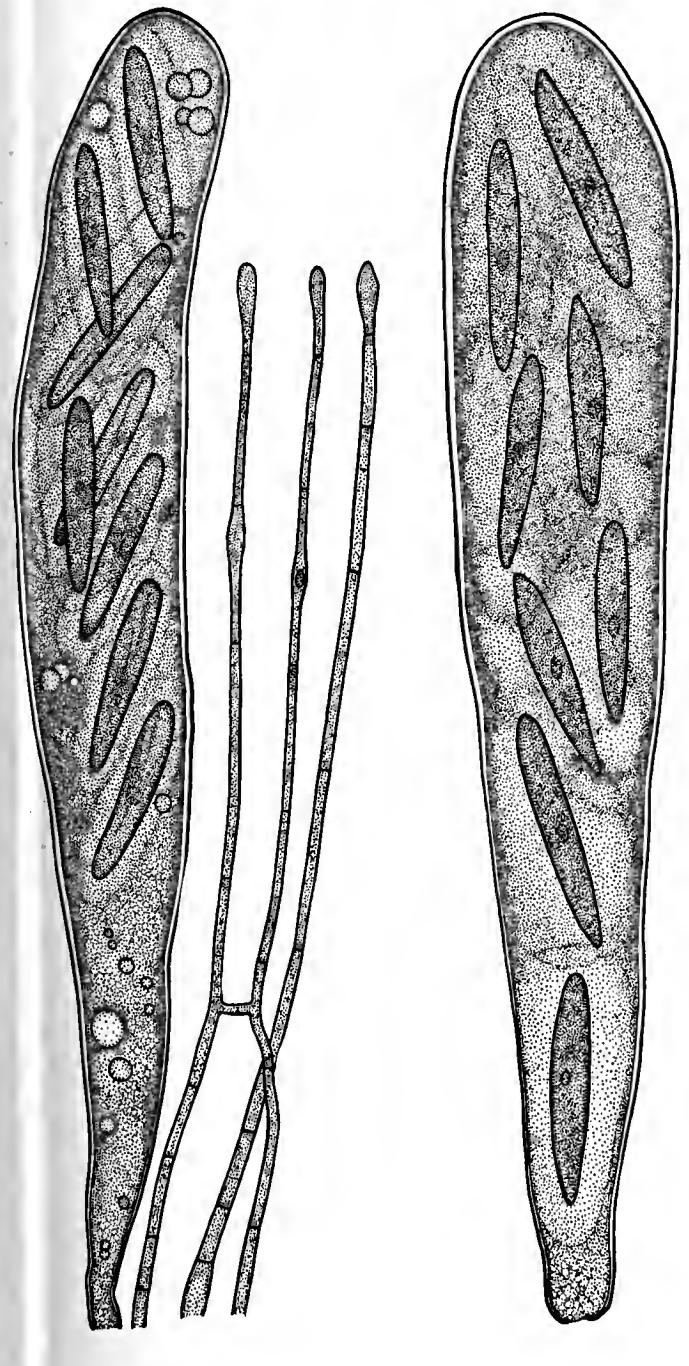
THE HYPODERMATACEAE OF CONIFERS.



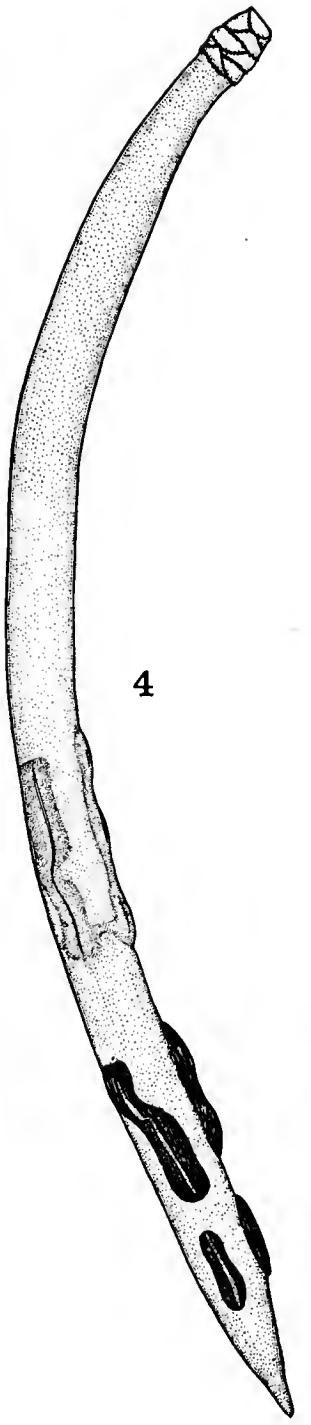
1



2

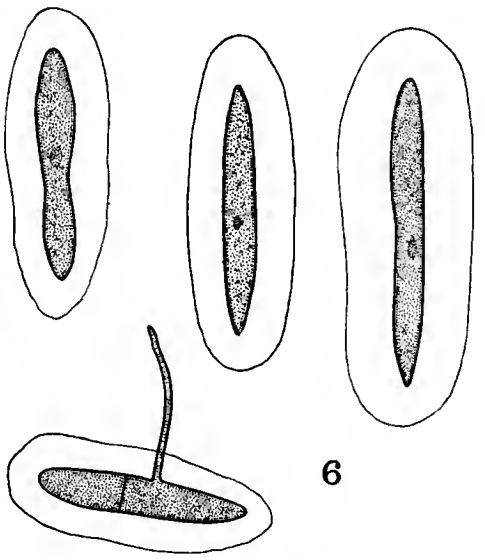


3

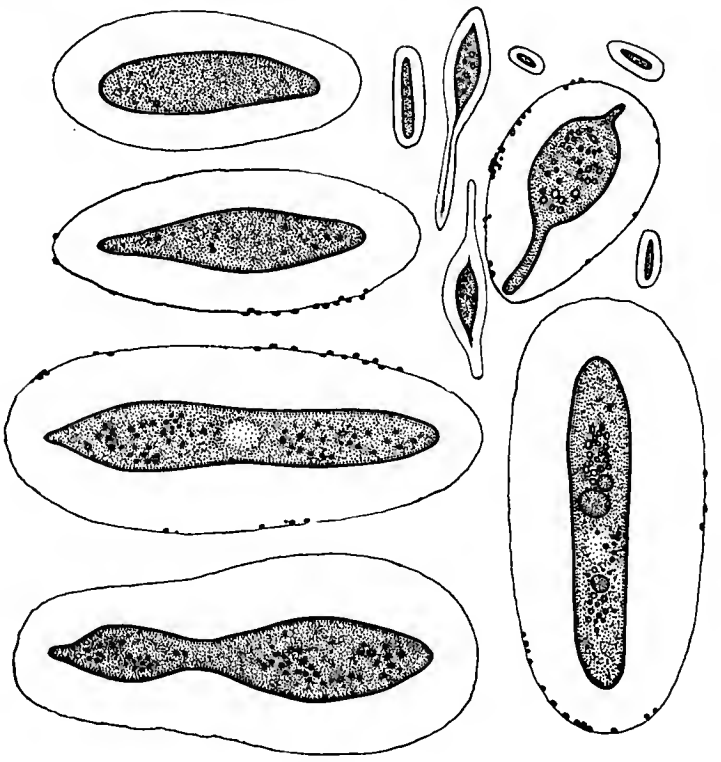


4

5

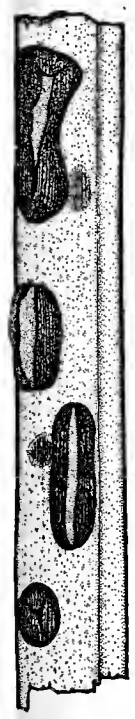


6

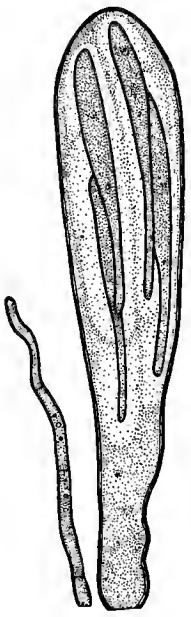


7

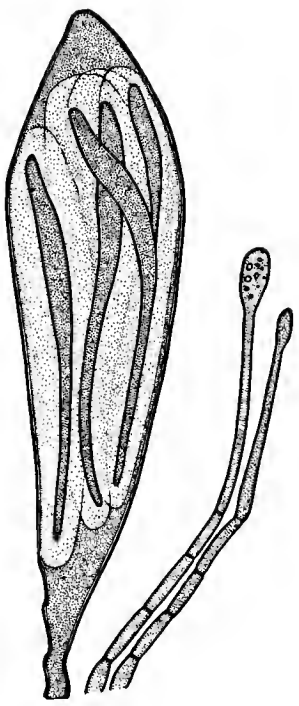
THE HYPODERMATACEAE OF CONIFERS.



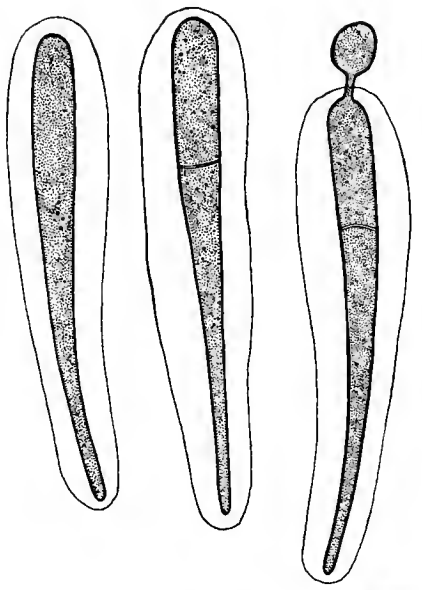
1

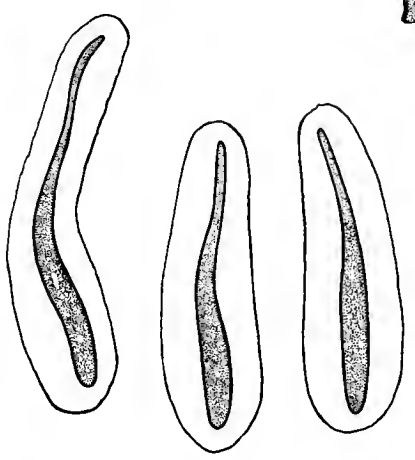


2

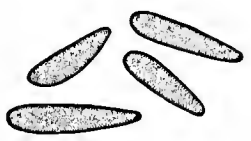


3

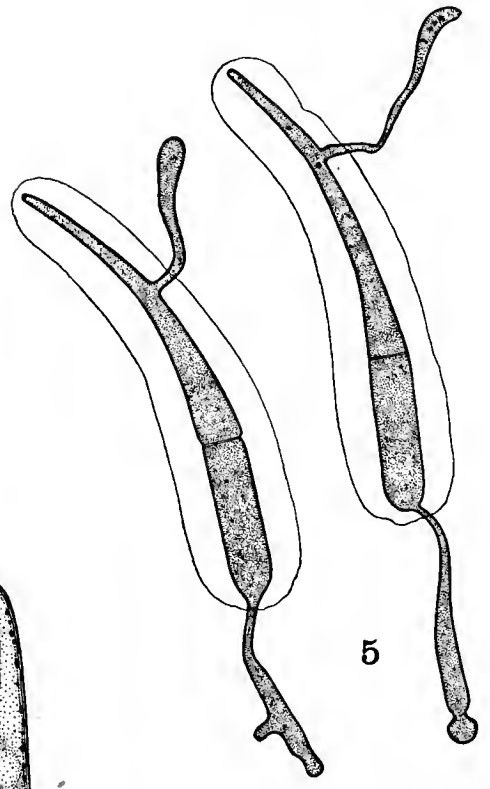




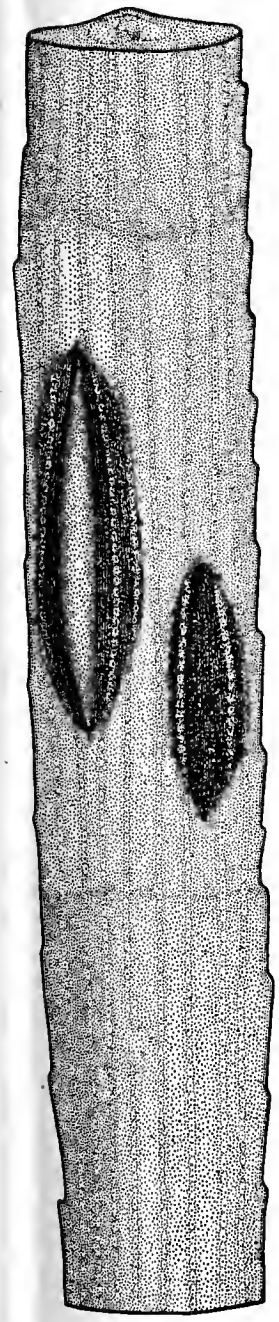
4



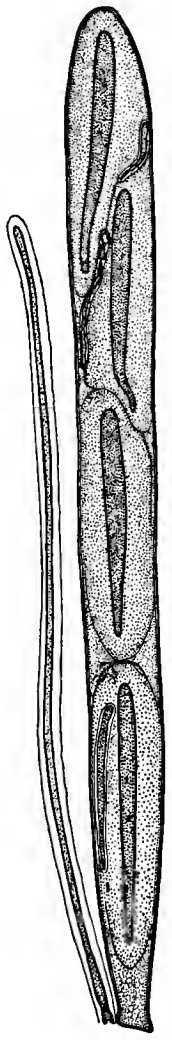
6



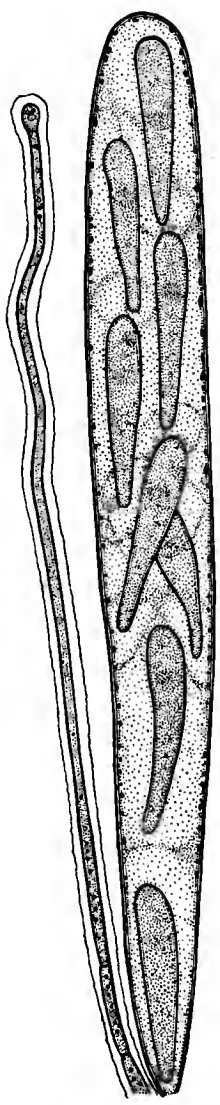
5



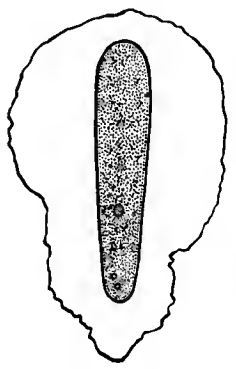
7

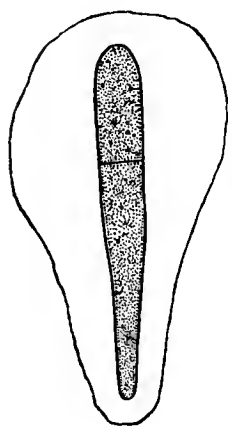


8



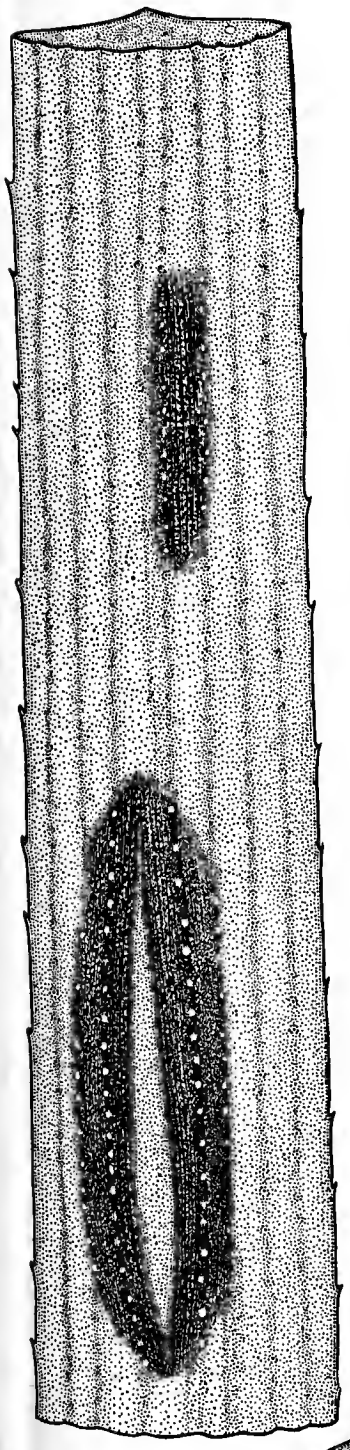
9



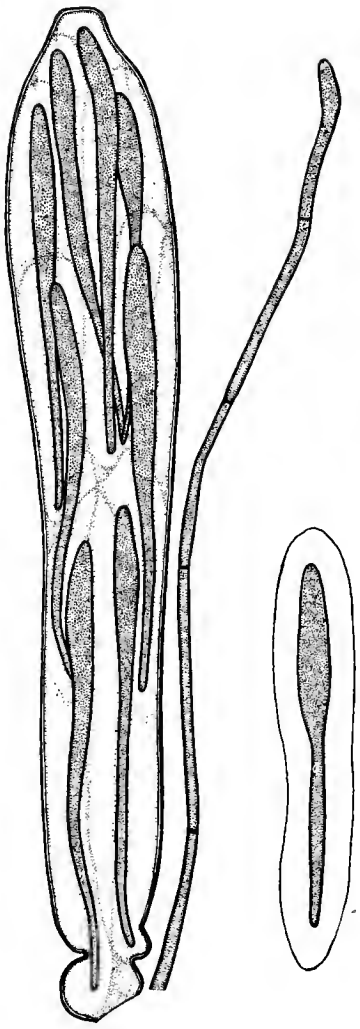


10

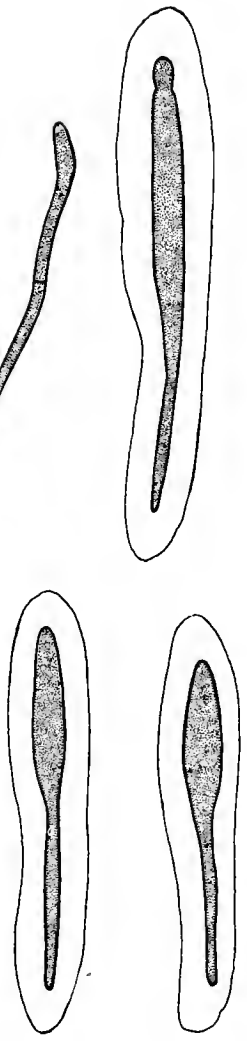
THE HYPODERMATACEAE OF CONIFERS.



1



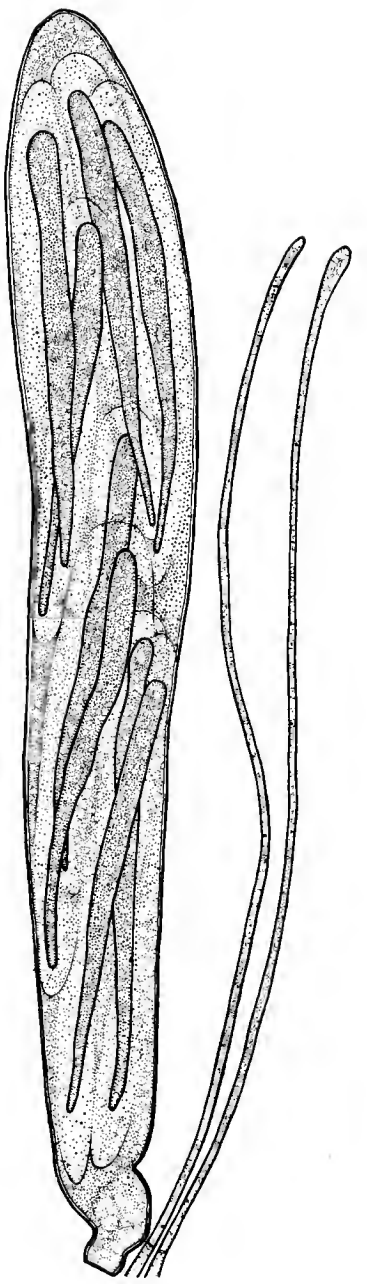
2



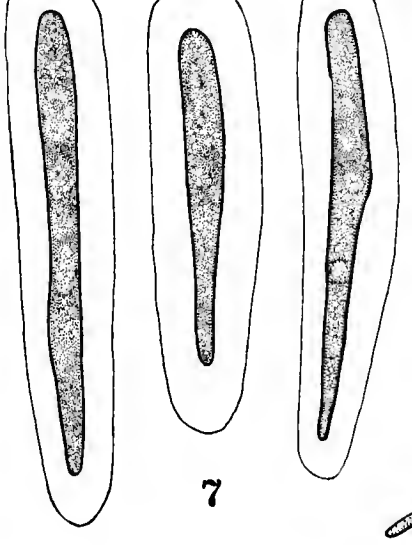
3

4

5



6

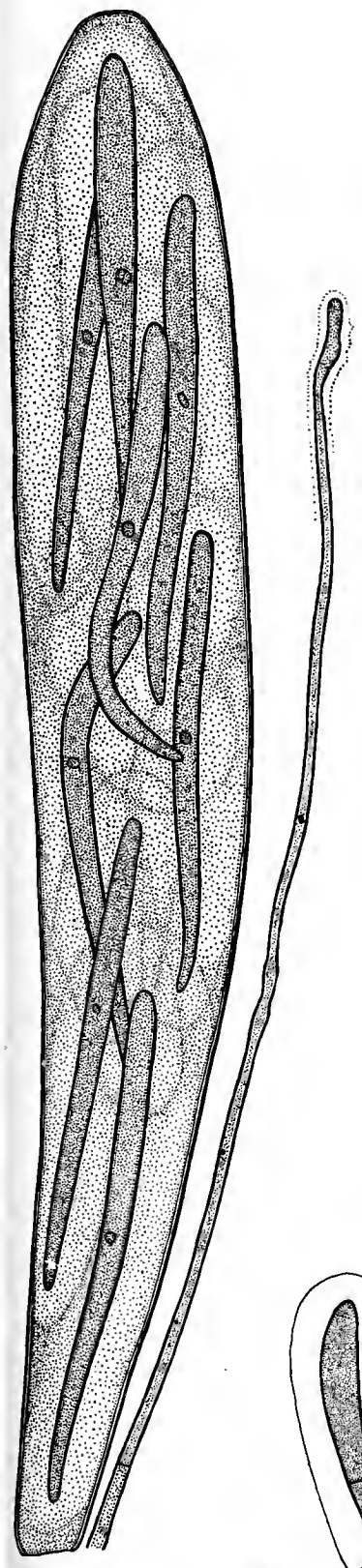


7

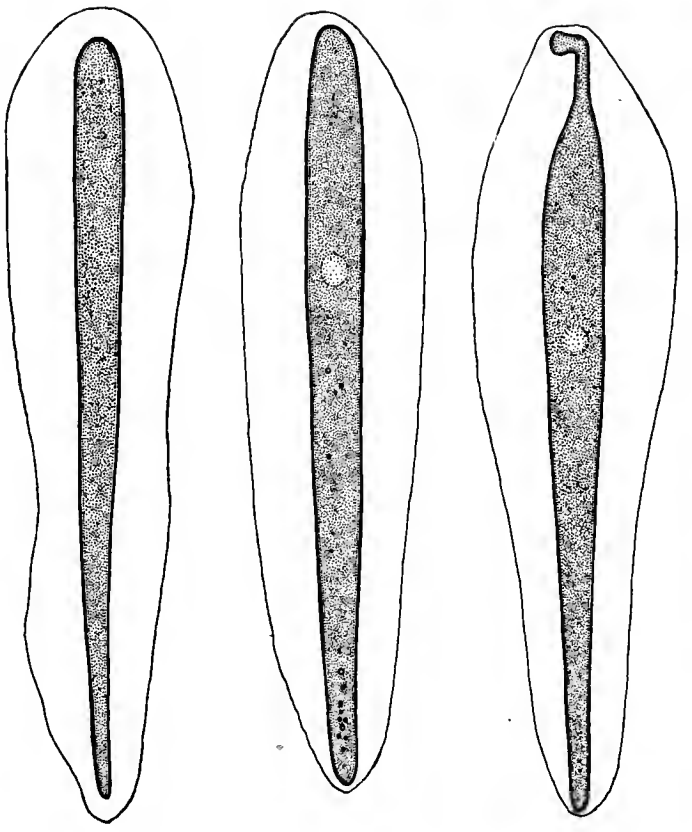
8

9

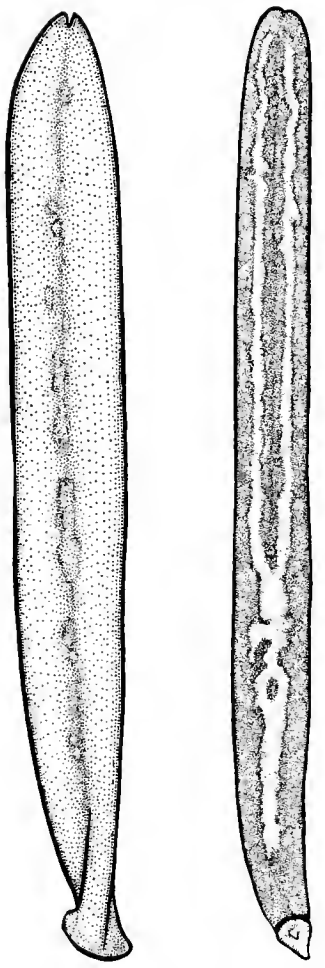
THE HYPODERMATACEAE OF CONIFERS.



1

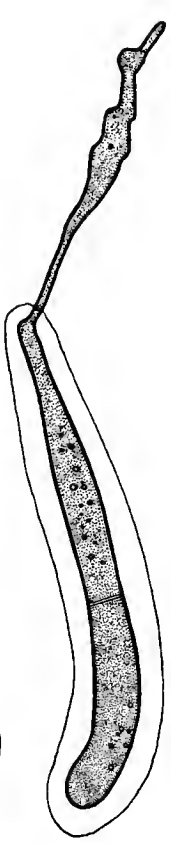


2

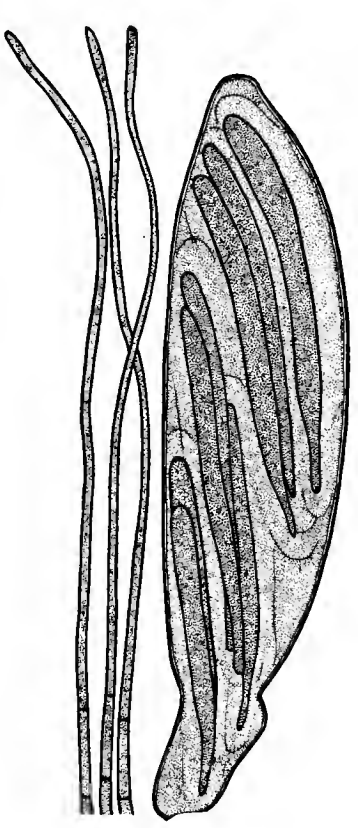


3

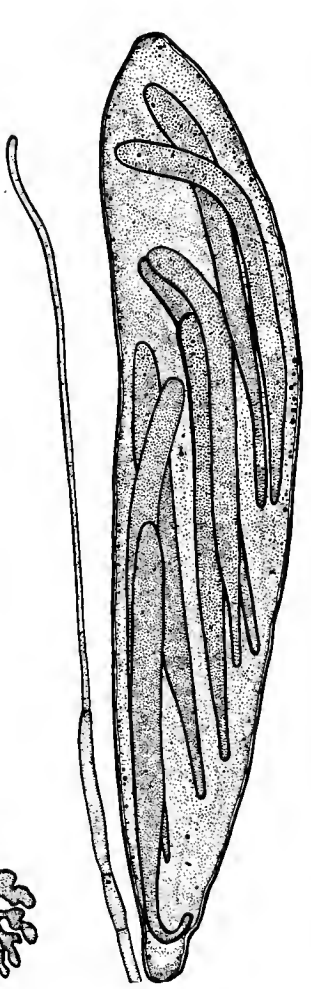
4



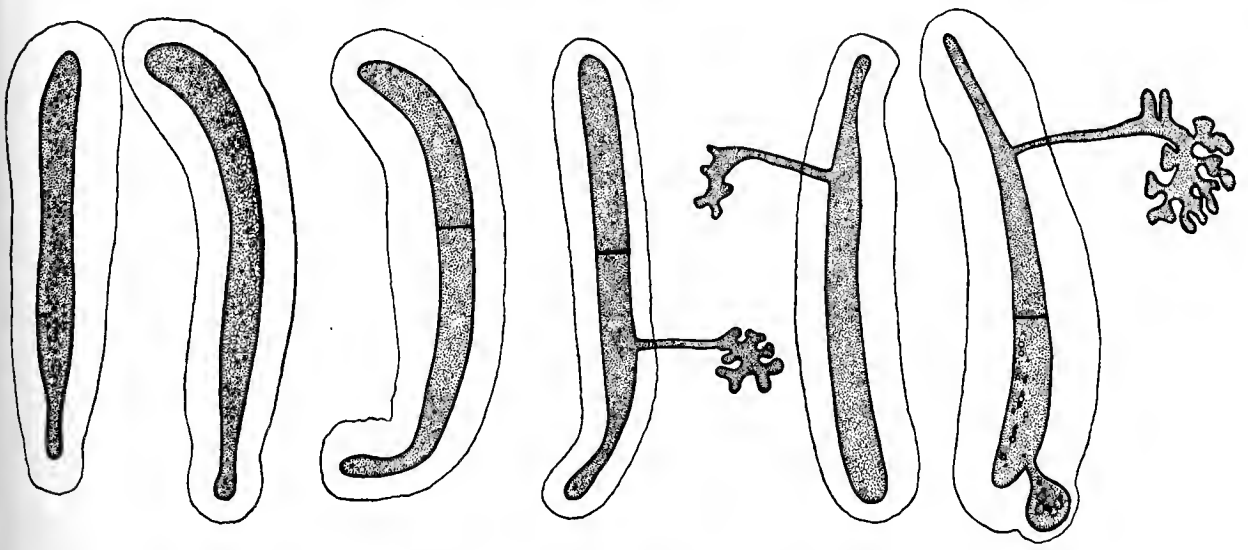
7

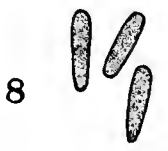


5

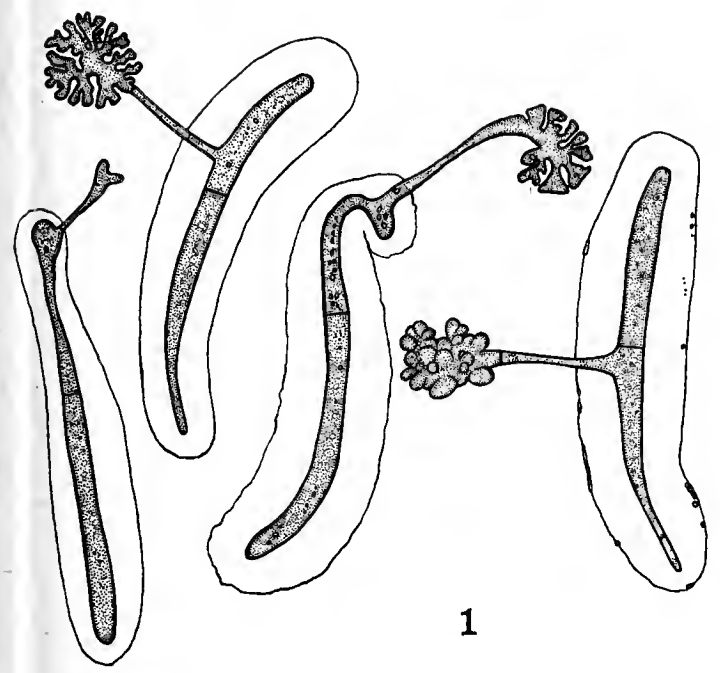


6

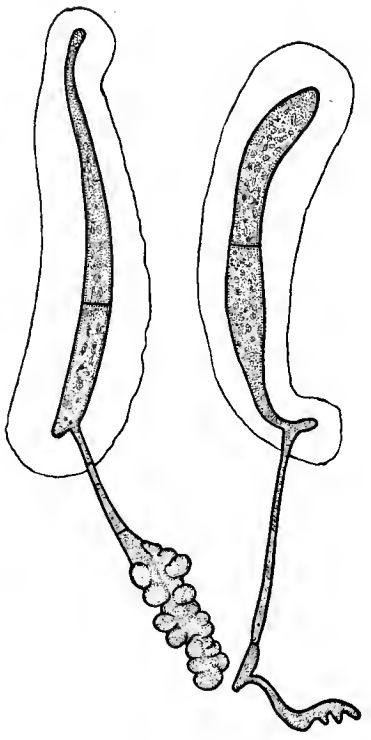


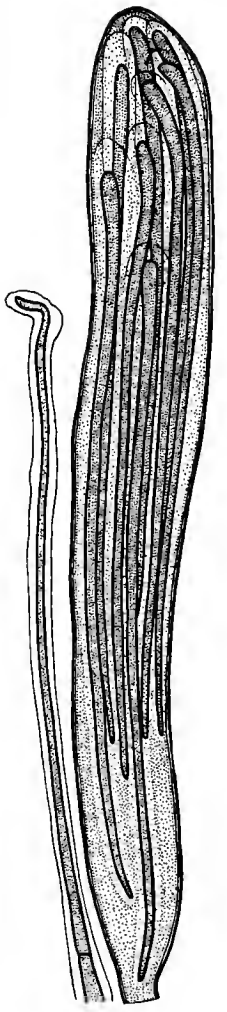


8

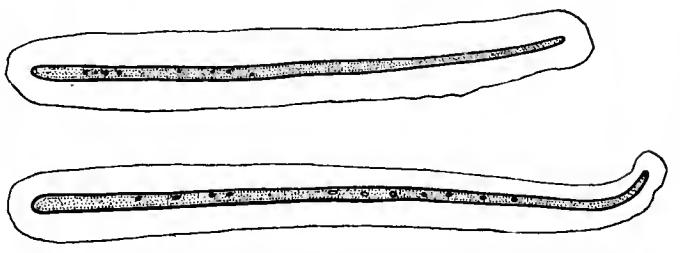


1

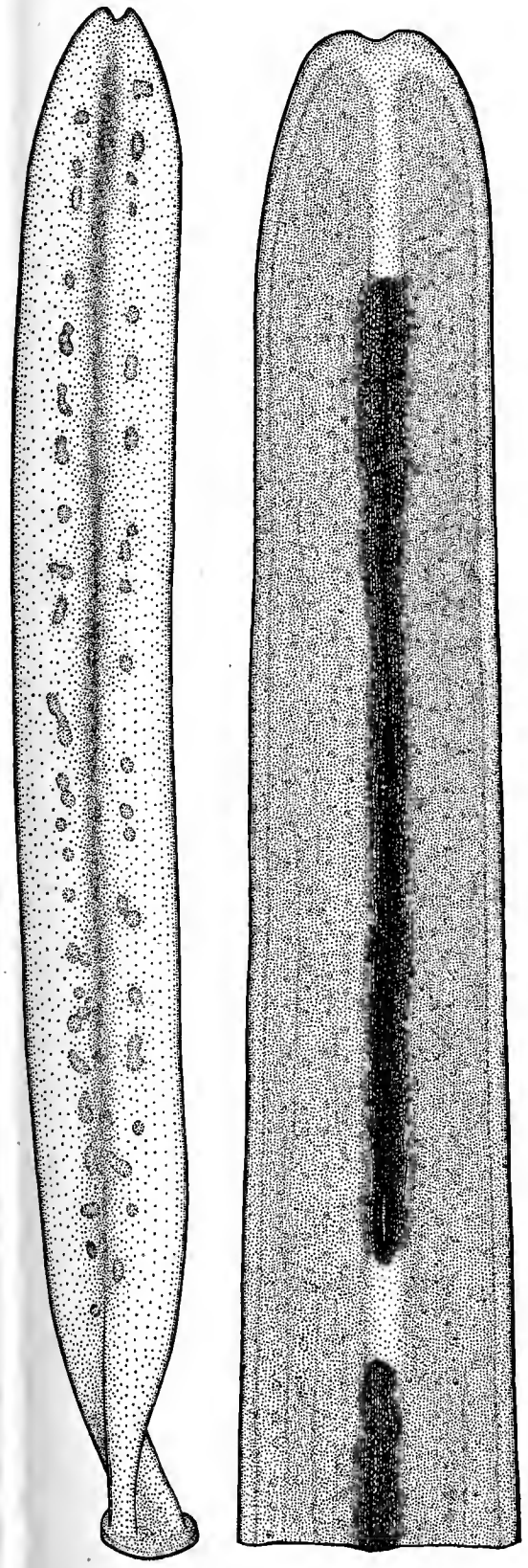




5

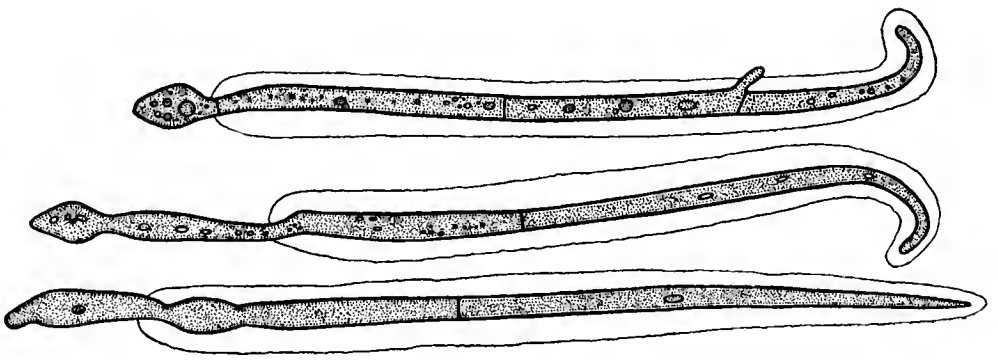


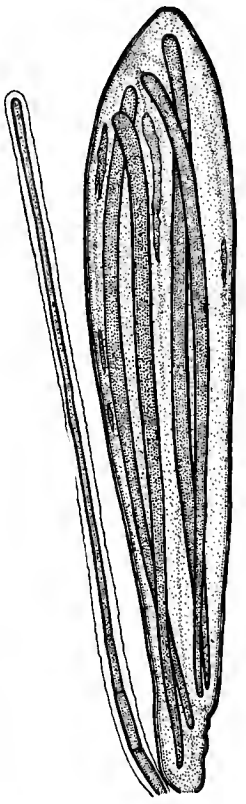
6



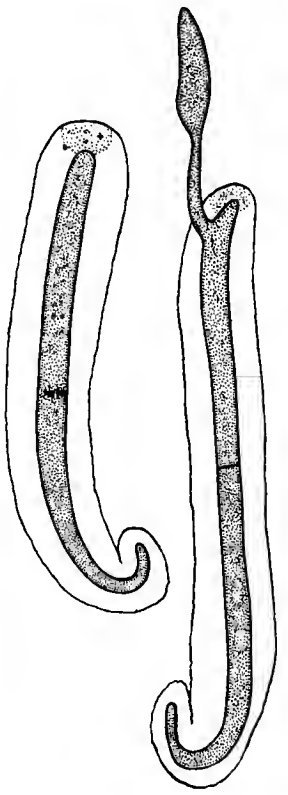
2

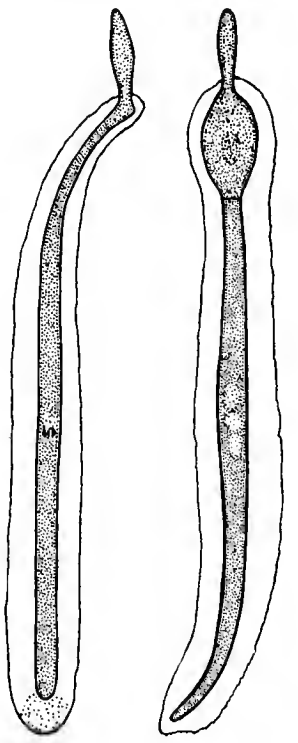
3





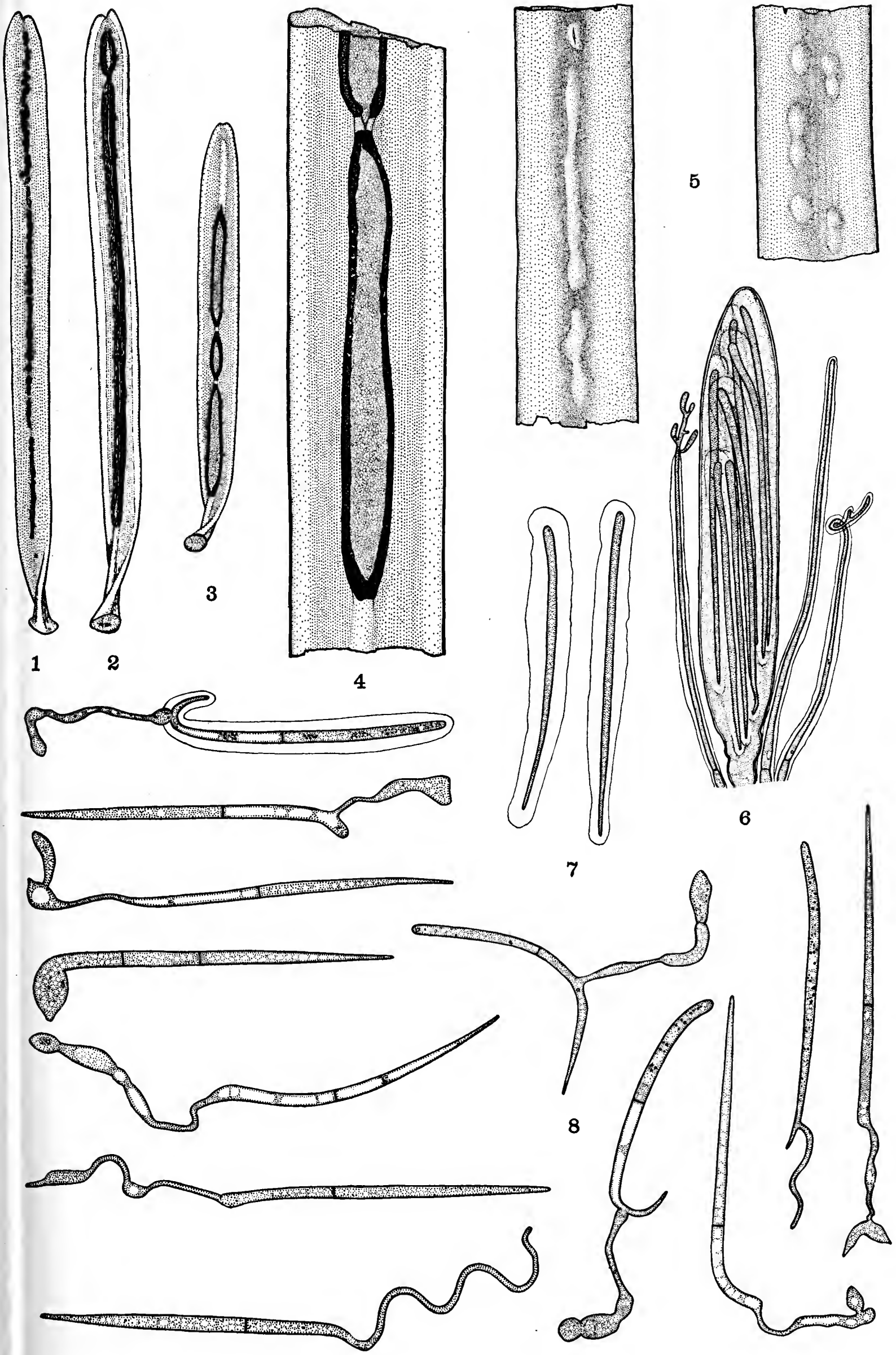
4



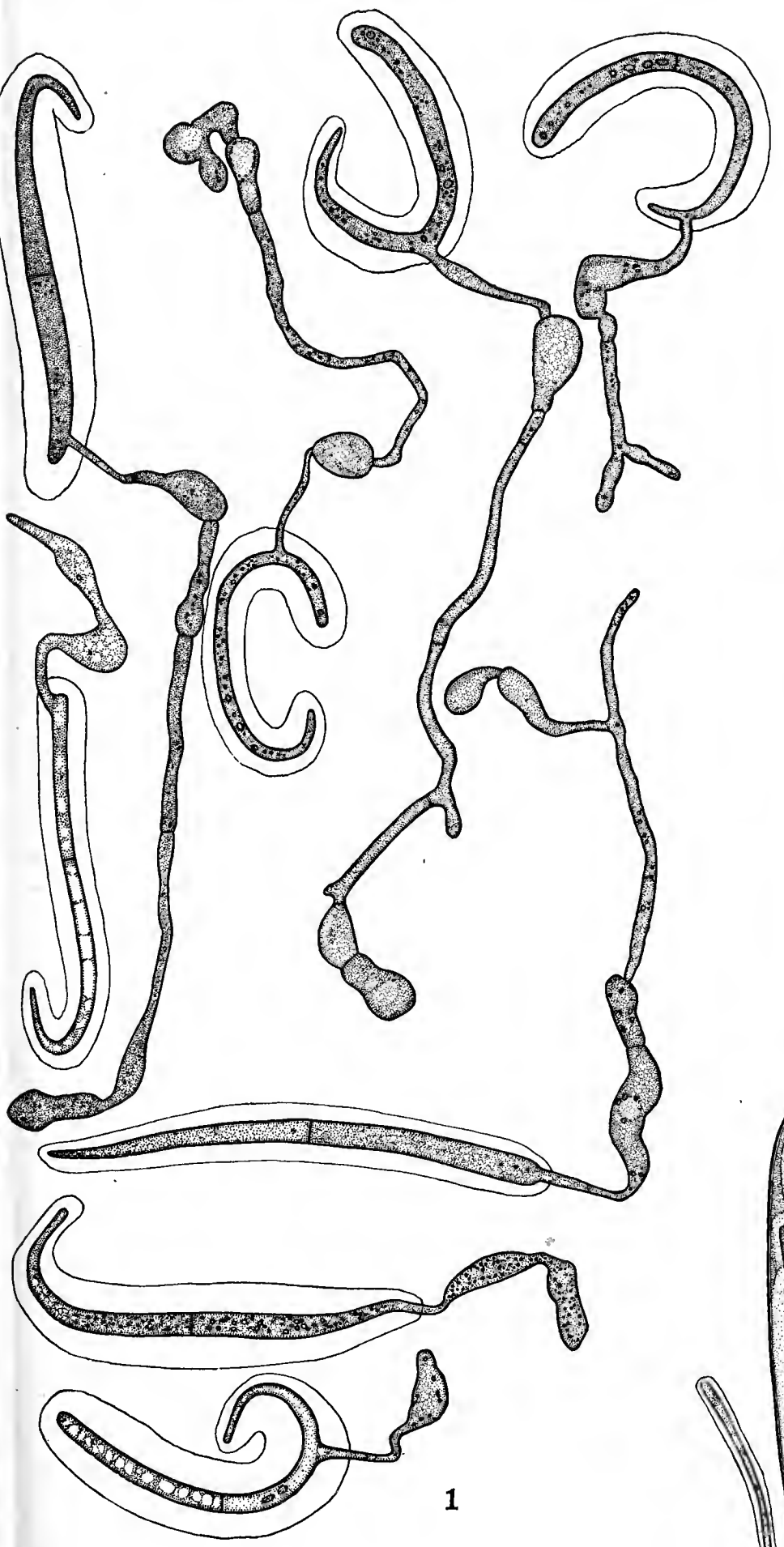


7

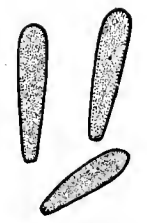
THE HYPODERMATACEAE OF CONIFERS.



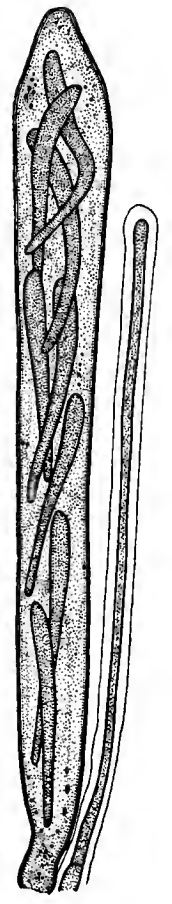
THE HYPODERMATACEAE OF CONIFERS.



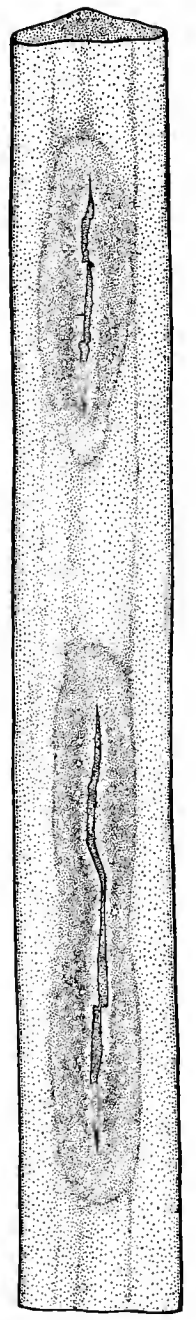
1



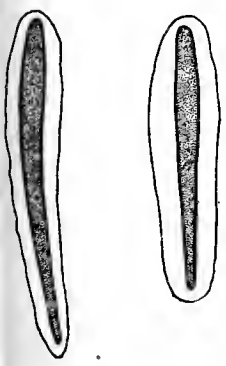
2



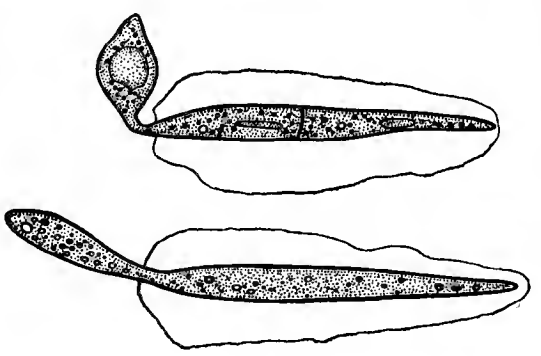
3



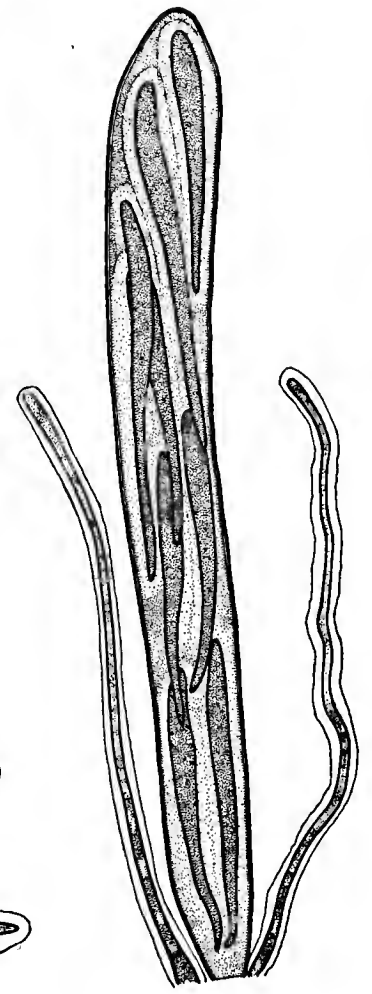
7



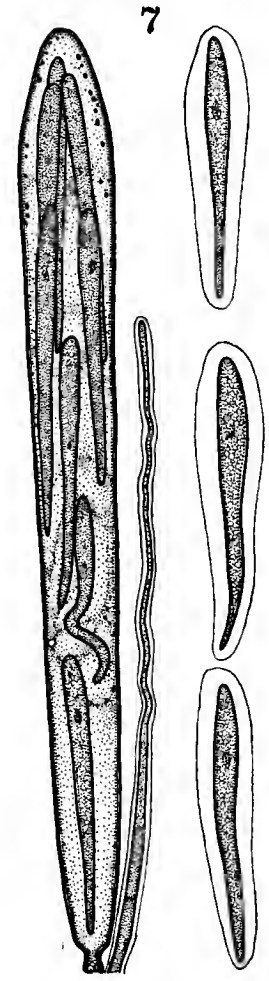
5



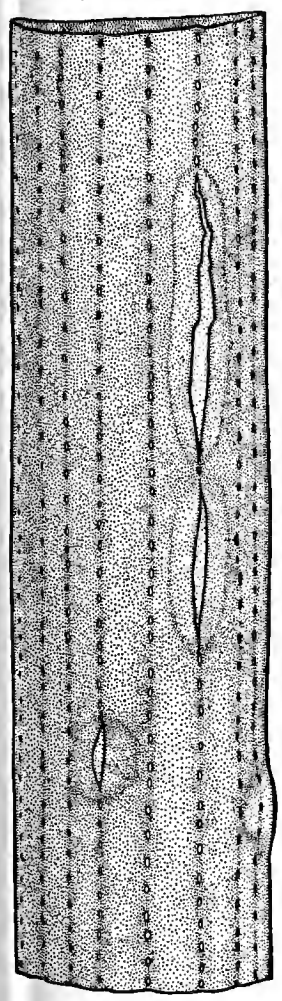
6



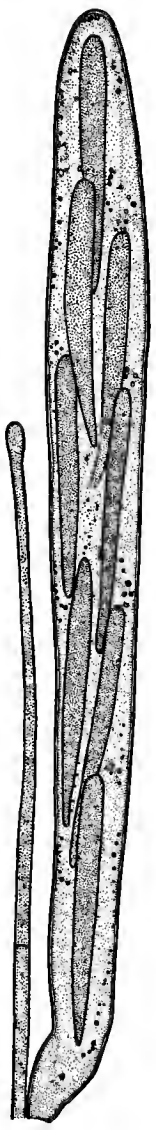
4



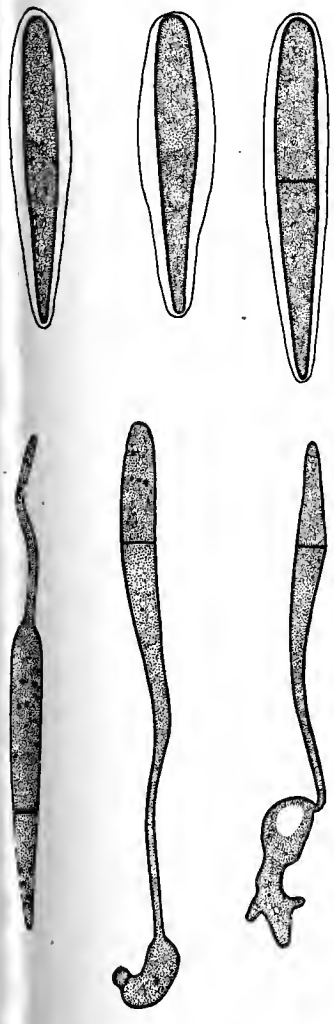
8 9



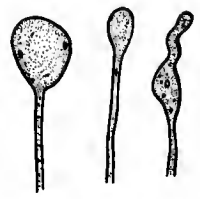
1



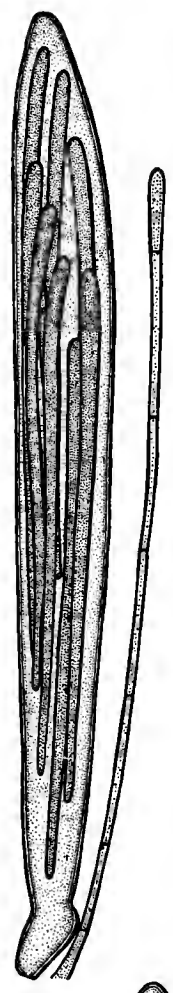
2



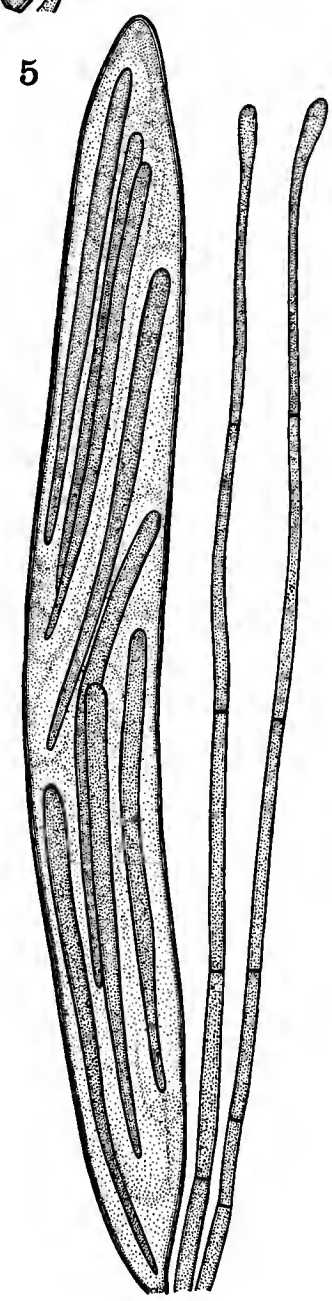
3



4

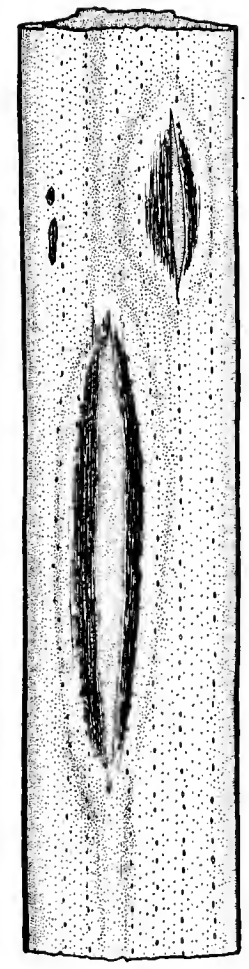


5

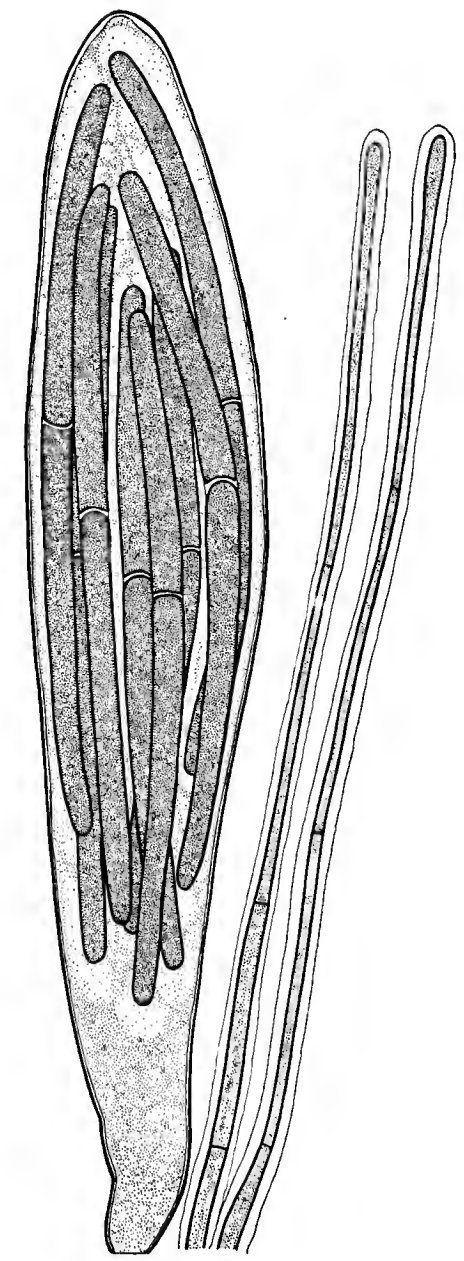


6

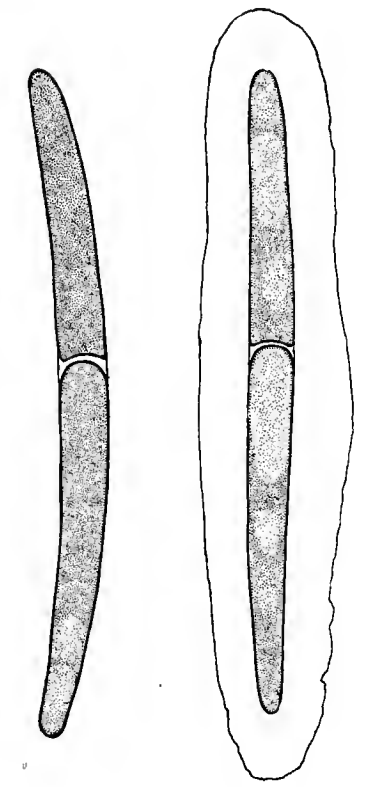
7



8

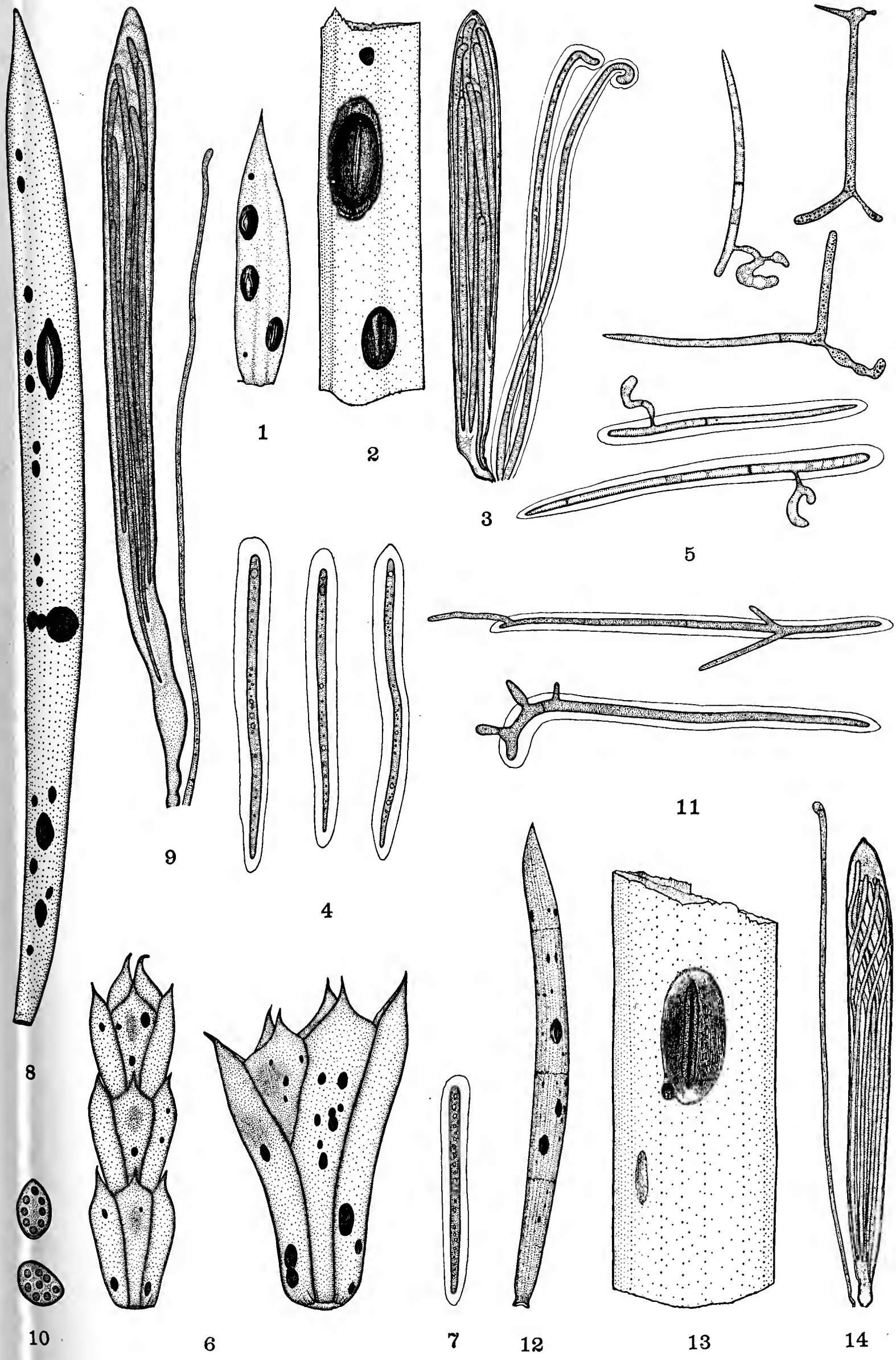


9

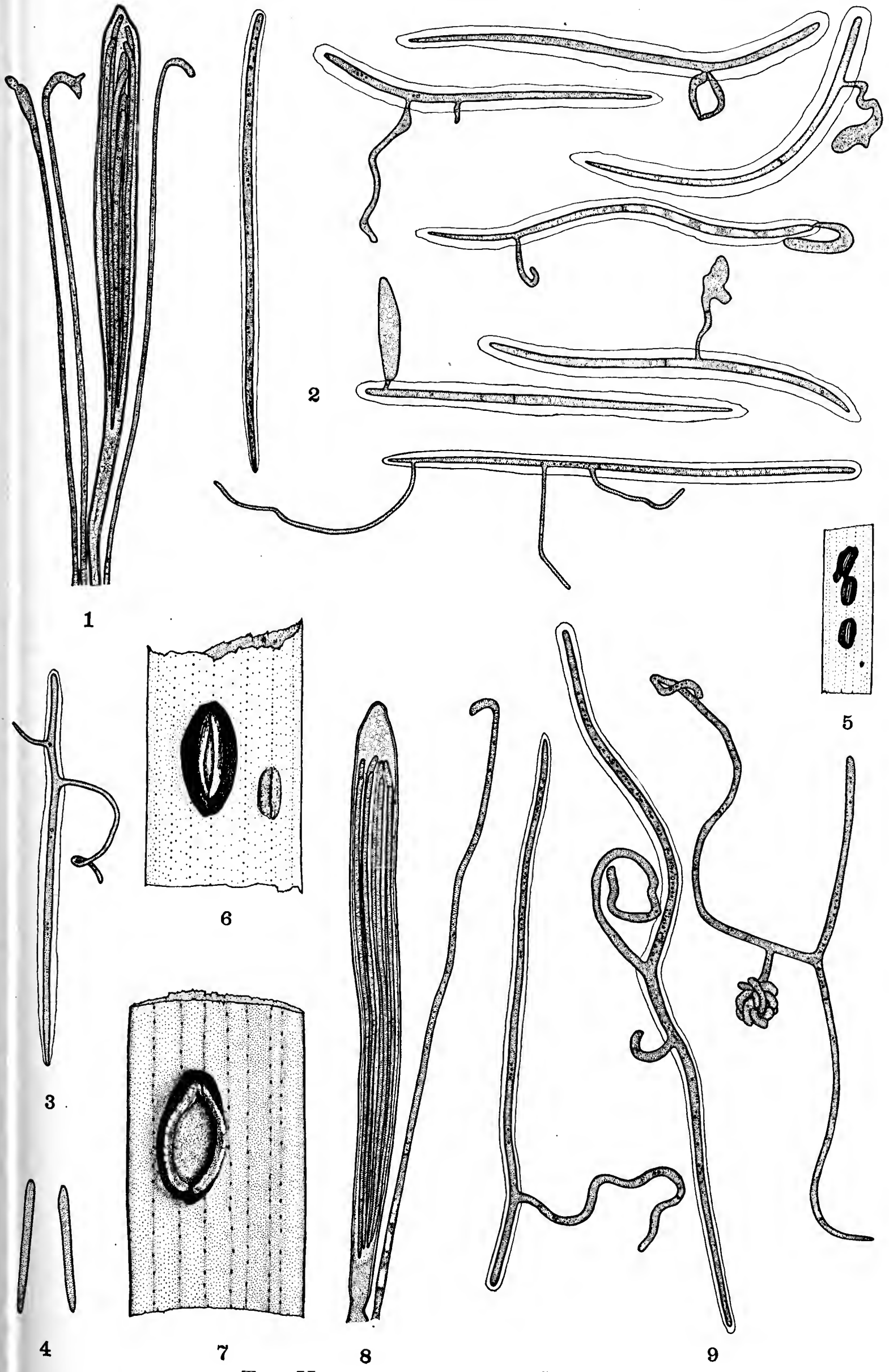


10

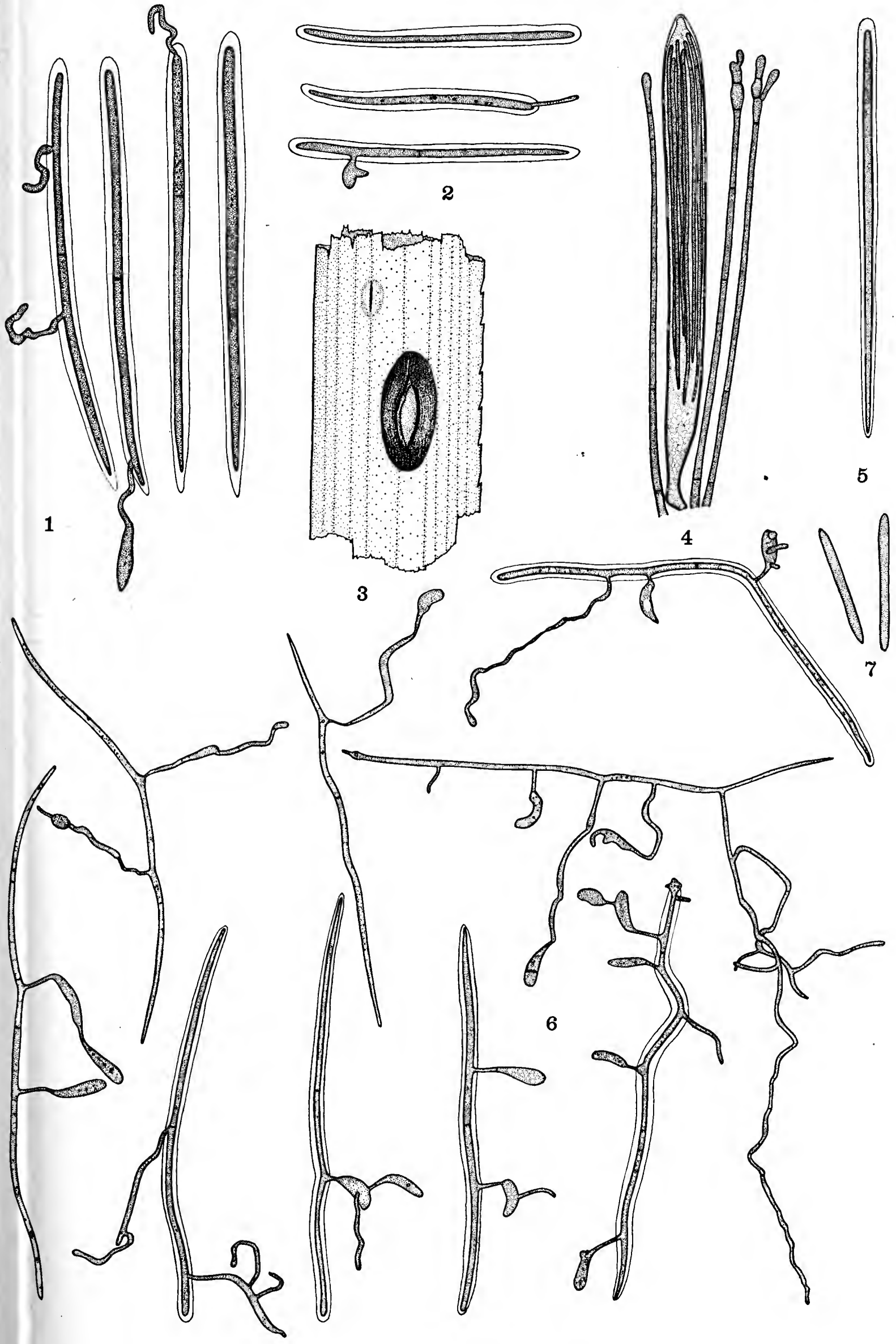
THE HYPODERMATACEAE OF CONIFERS.



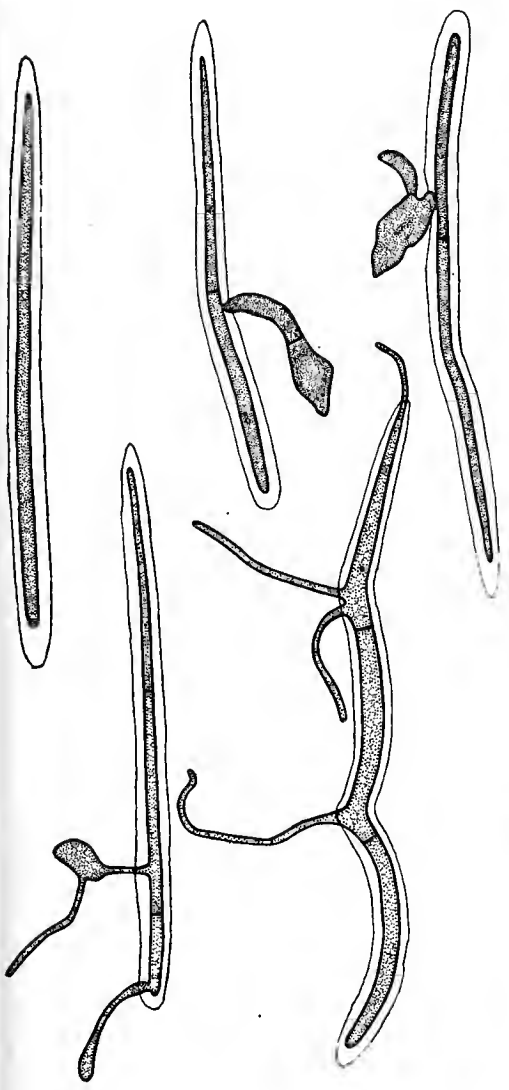
THE HYPODERMATACEAE OF CONIFERS.



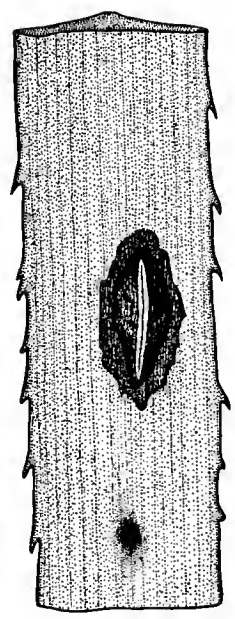
THE HYPODERMATACEAE OF CONIFERS.



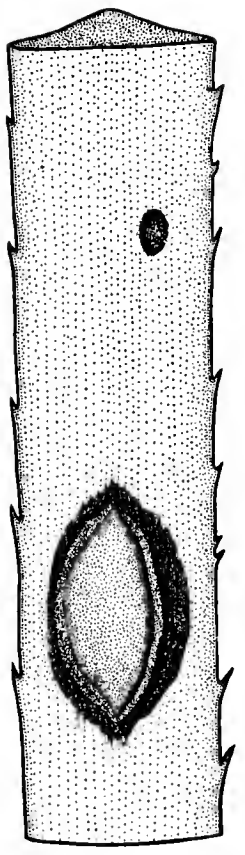
THE HYPODERMATACEAE OF CONIFERS.



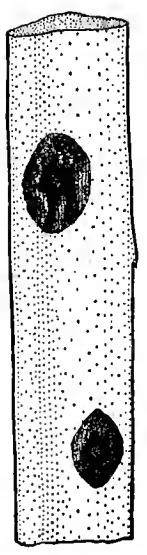
1



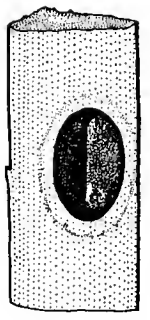
2



3

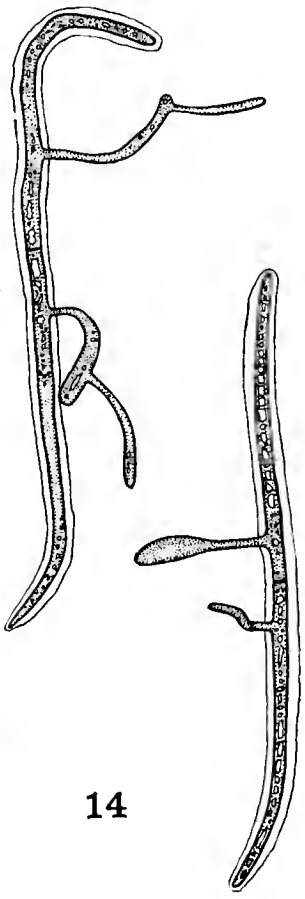


10



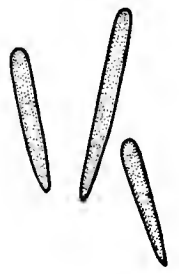
11

12



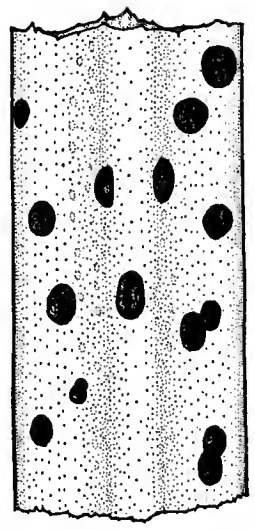
14

13

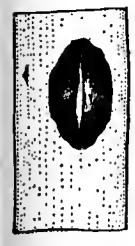


15

4

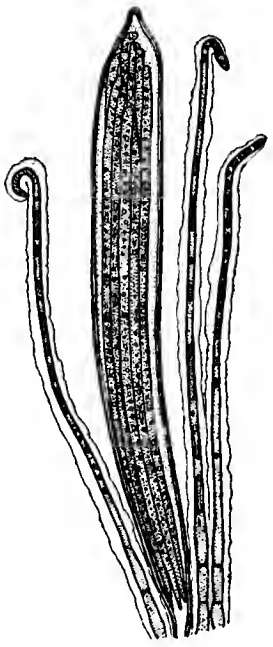


5

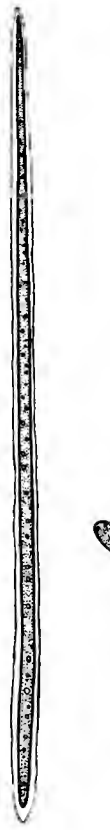


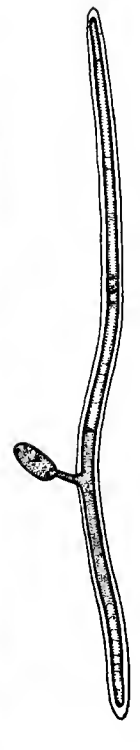
6

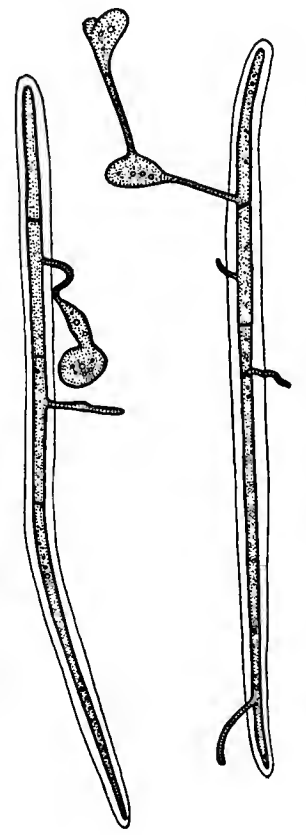
9



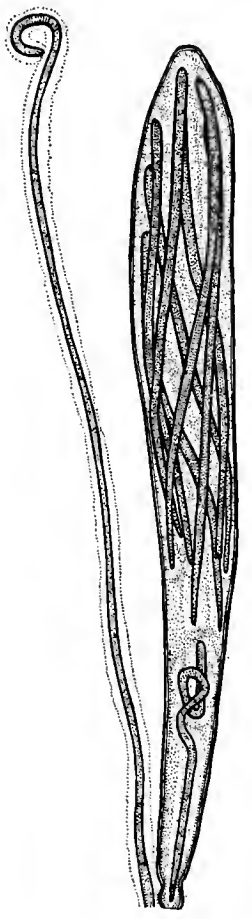
7





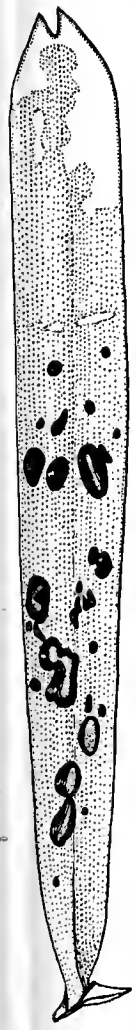


8

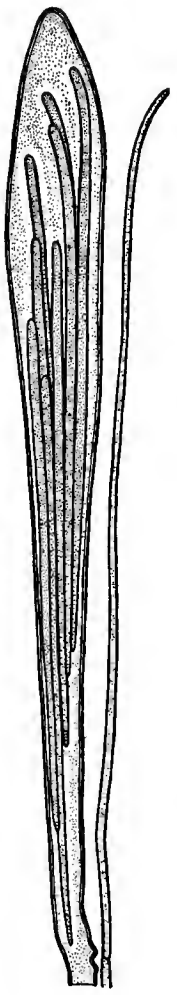


16

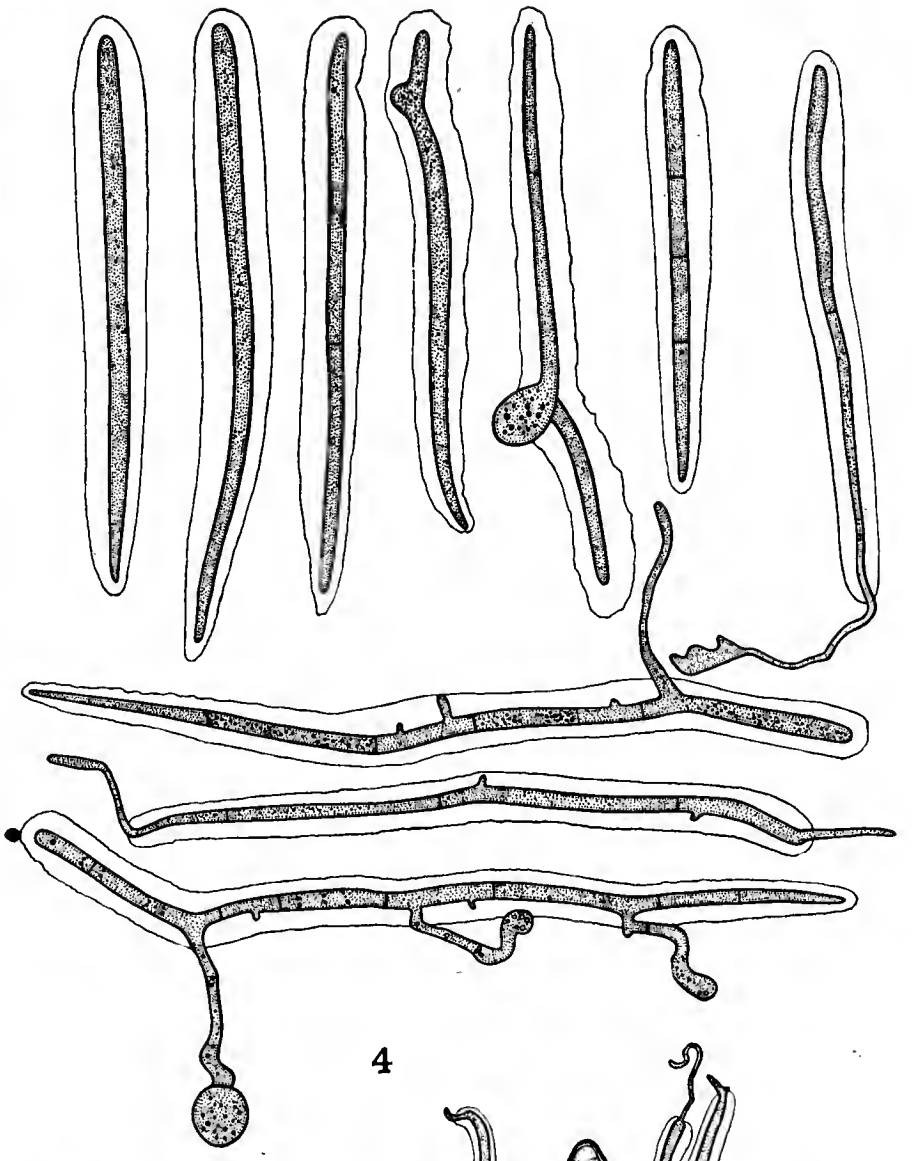
THE HYPODERMATACEAE OF CONIFERS.



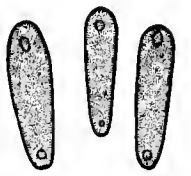
1



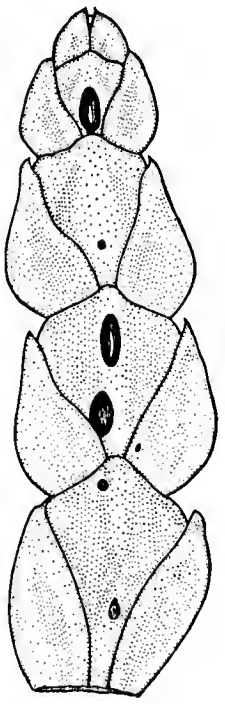
3



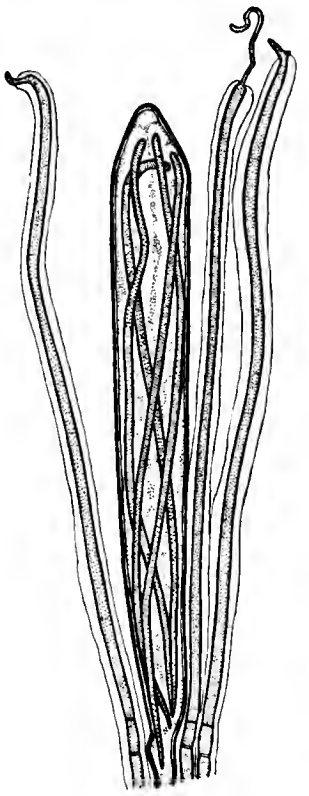
4



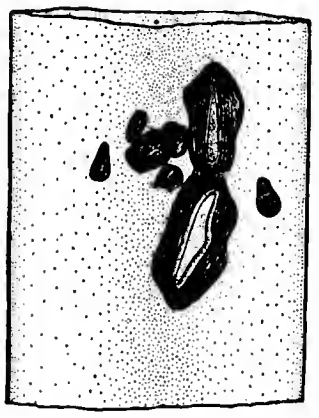
5



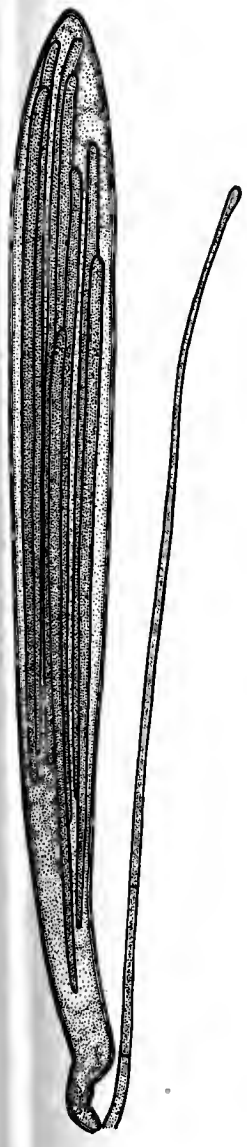
6



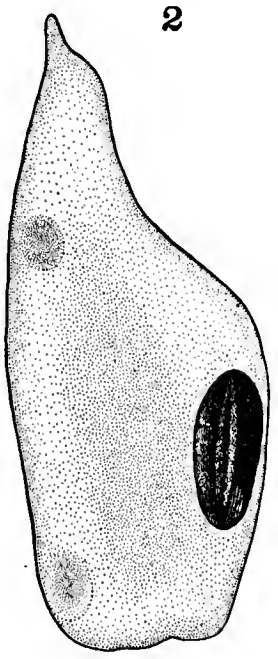
8



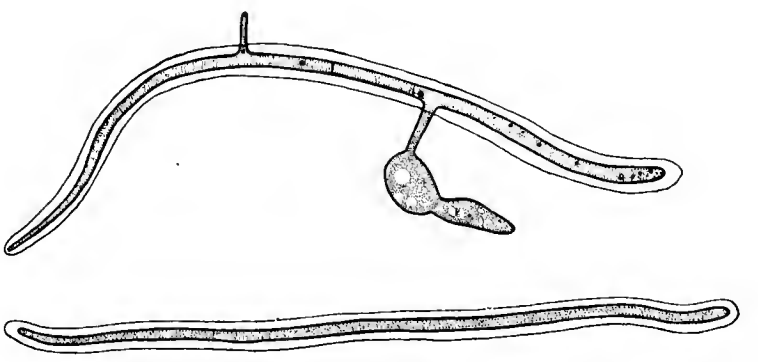
2



10



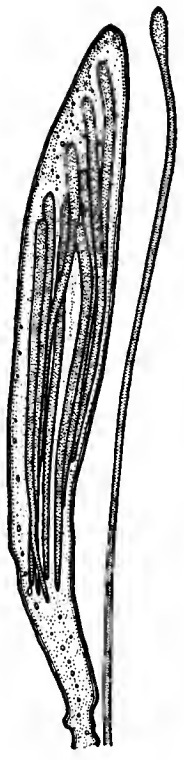
7



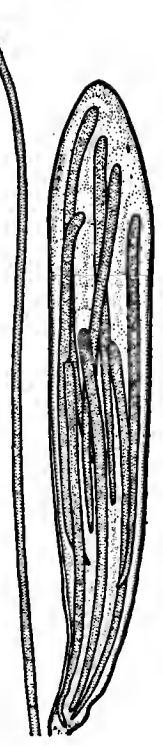
9

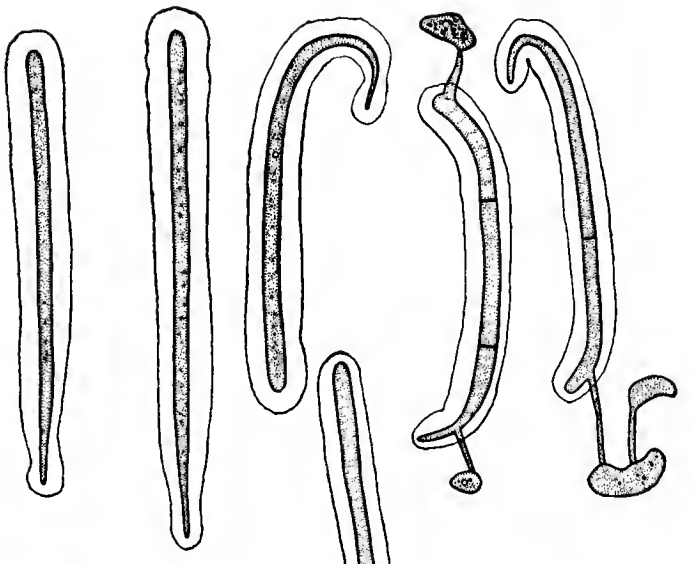
THE HYPODERMATACEAE OF CONIFERS.

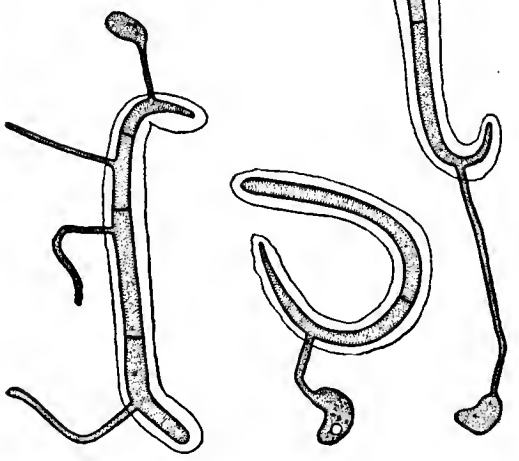
1

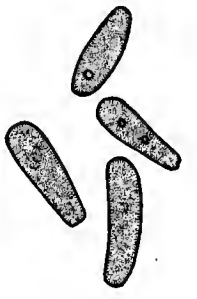


4

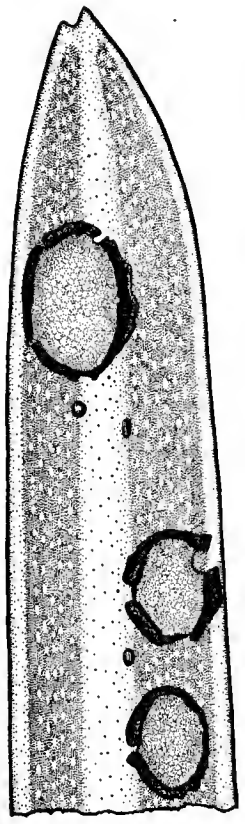




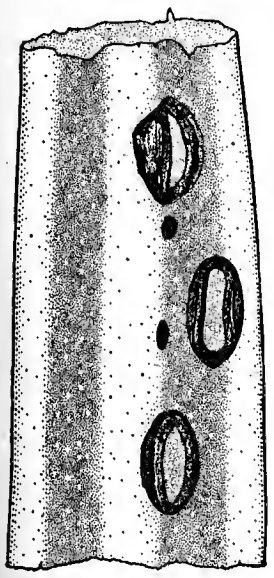




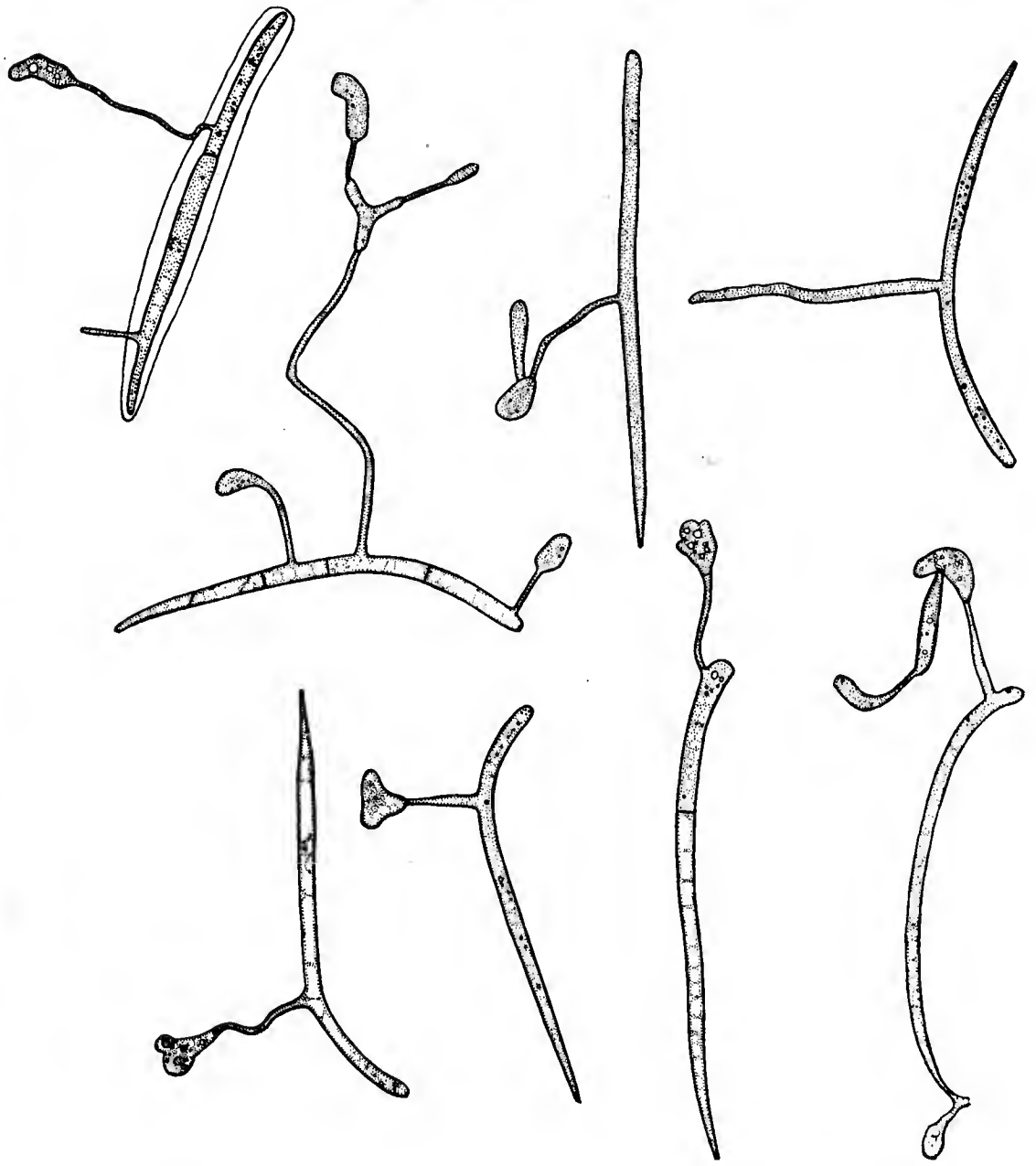
6



2

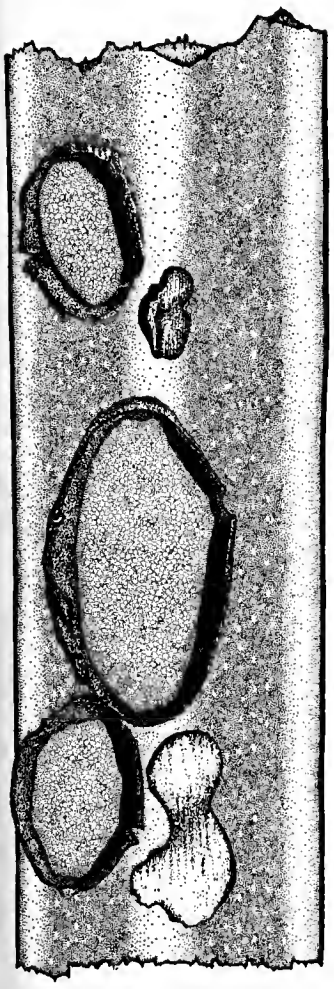


3

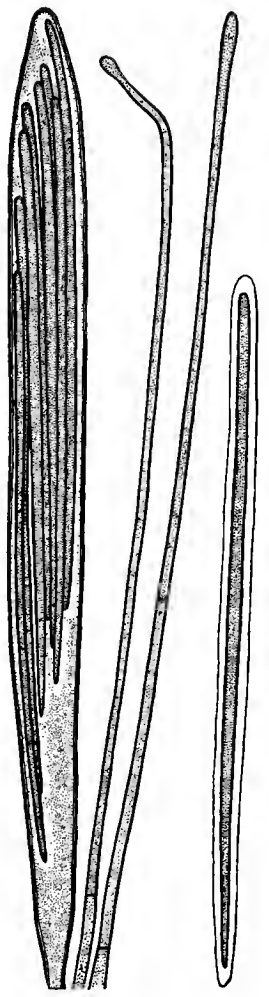


5

THE HYPODERMATACEAE OF CONIFERS.

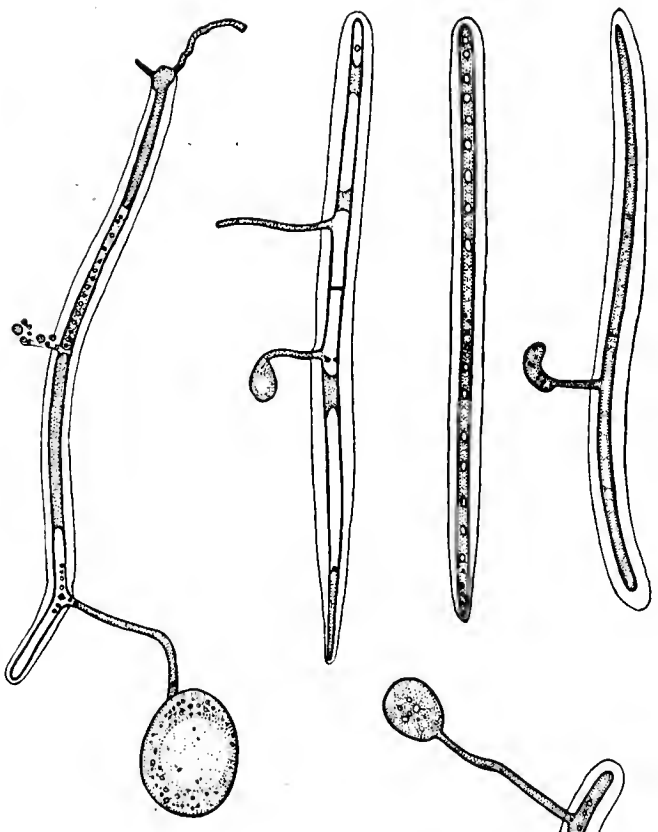


1

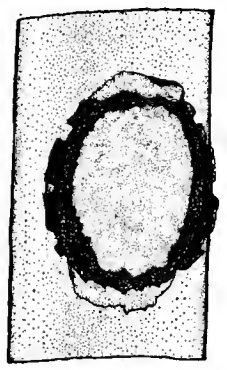


2 3

6

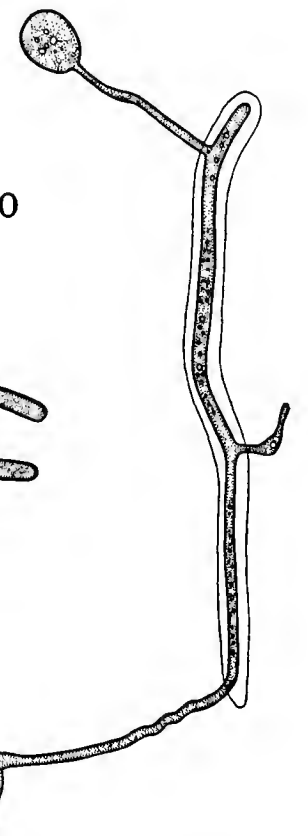


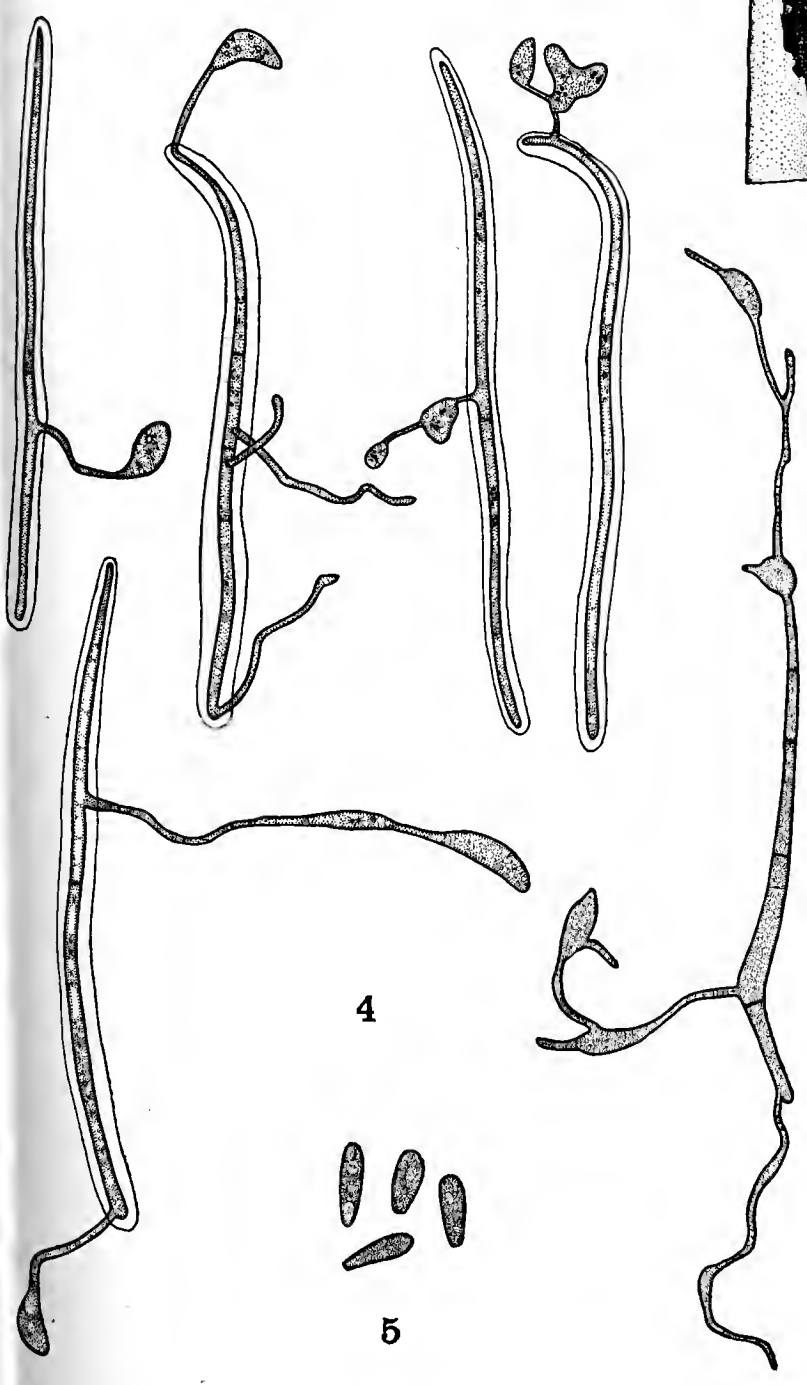
10



7

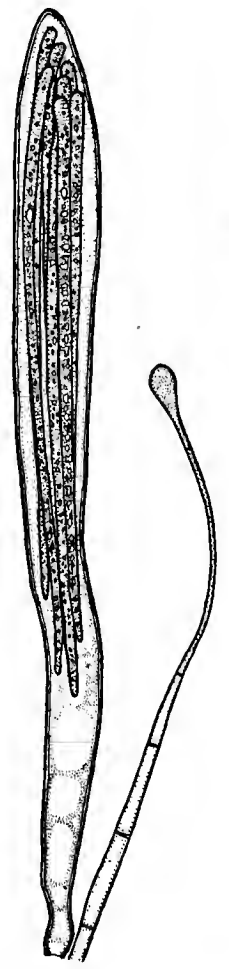
11



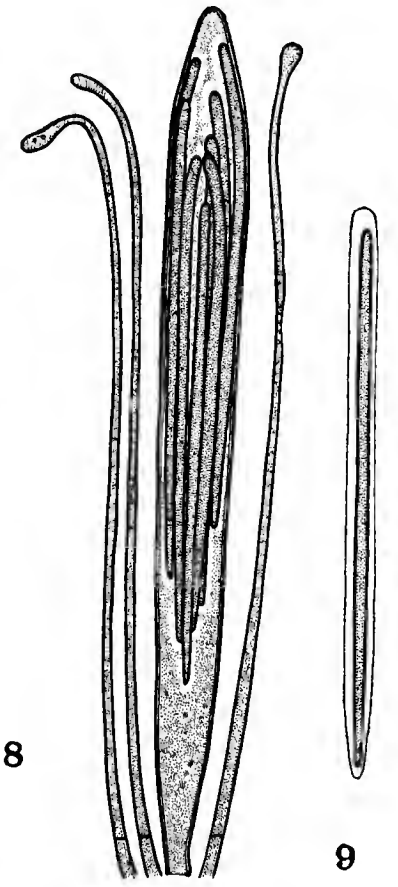


4

5

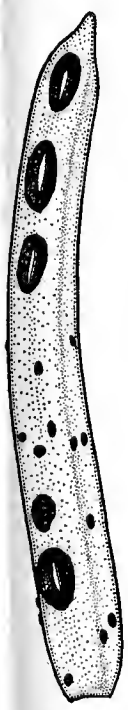


8

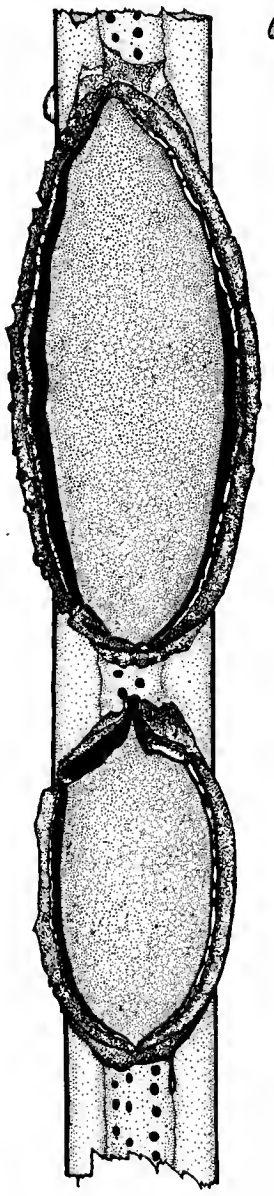


9

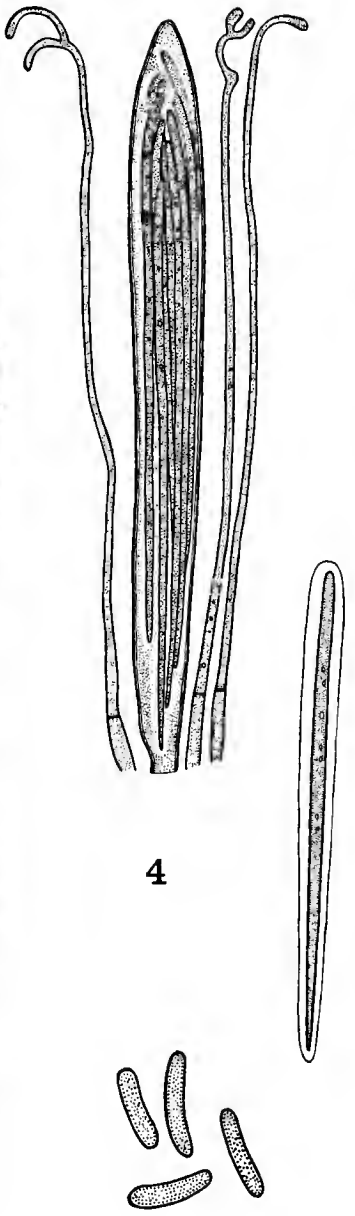
THE HYPODERMATACEAE OF CONIFERS.



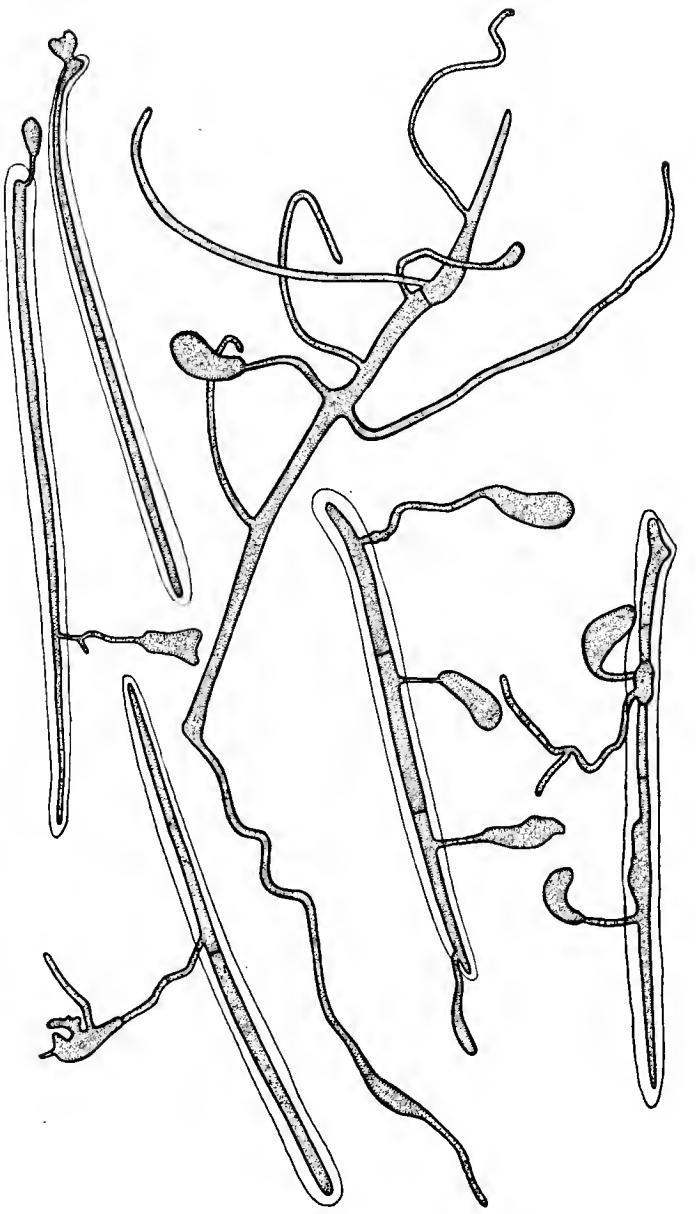
1



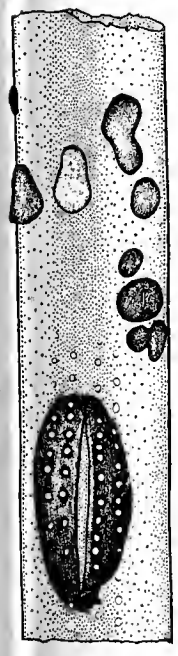
3



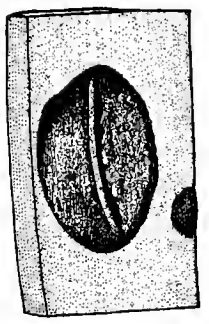
4



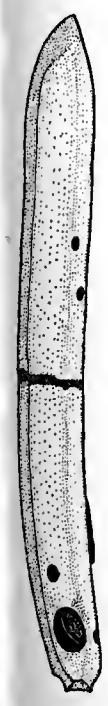
5



2



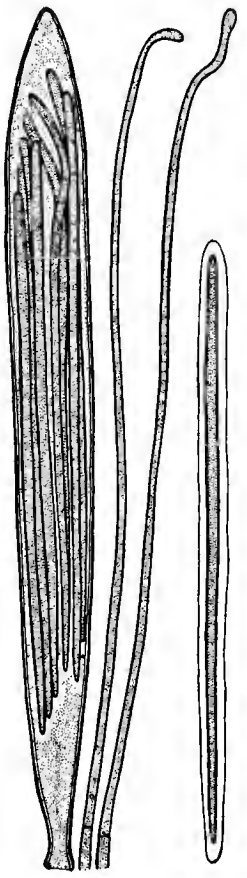
8



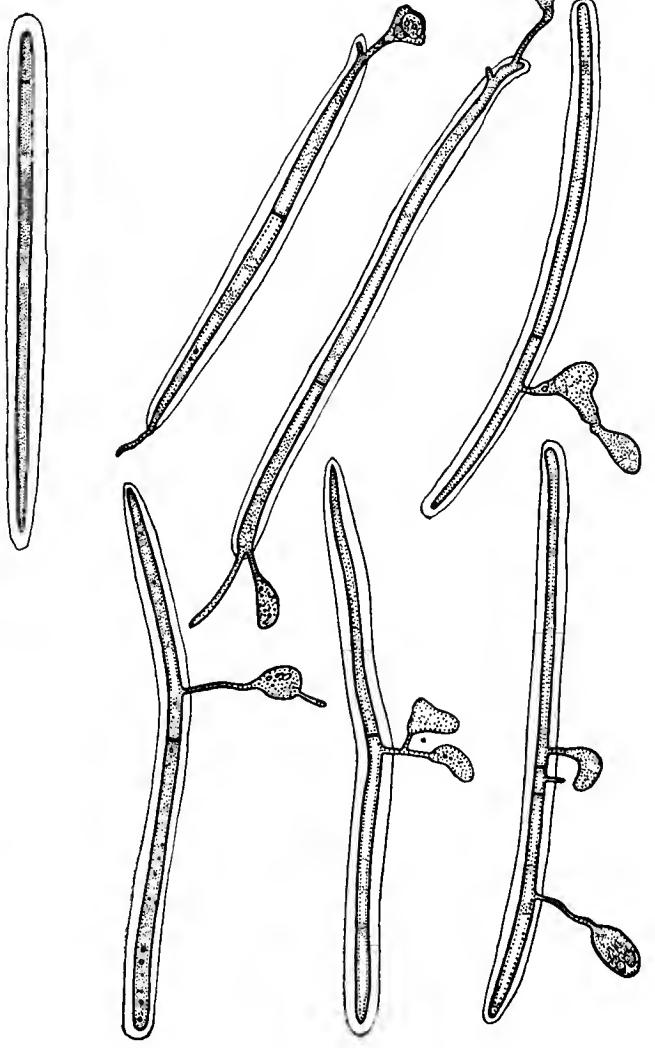
7

9

6

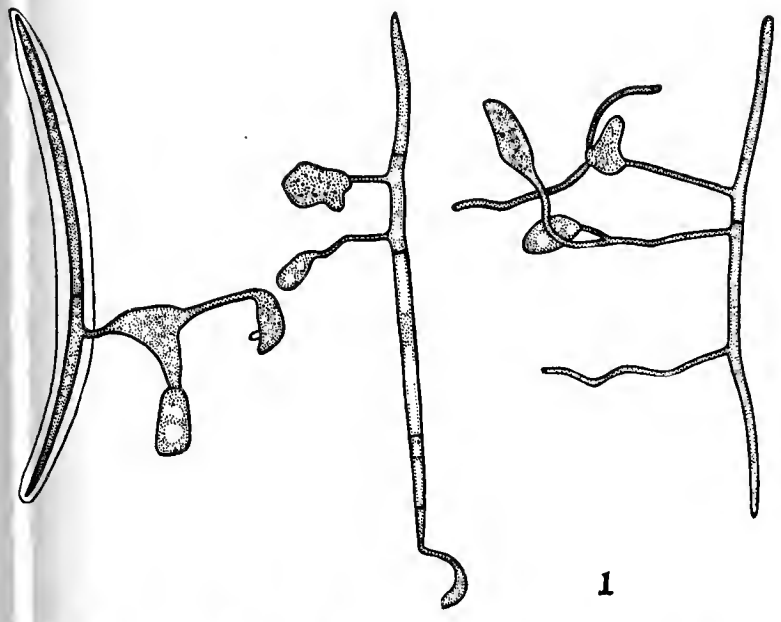


10

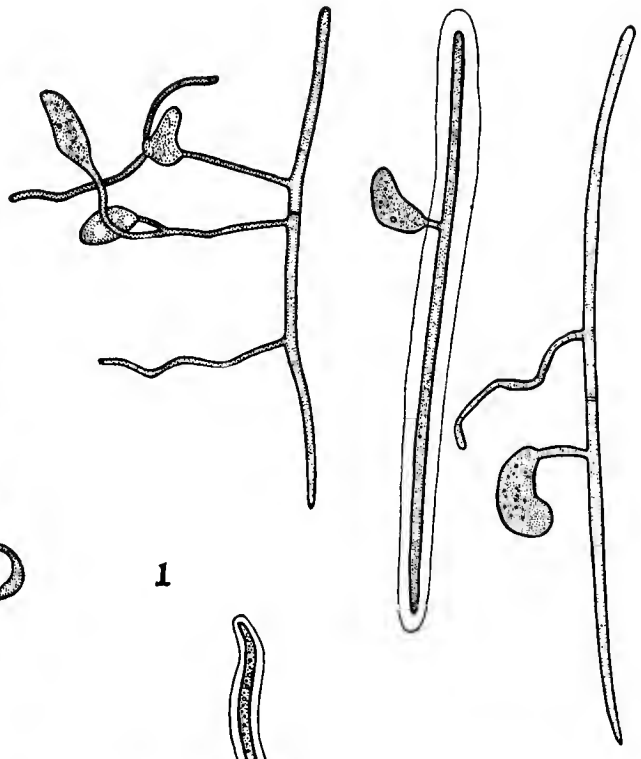


11

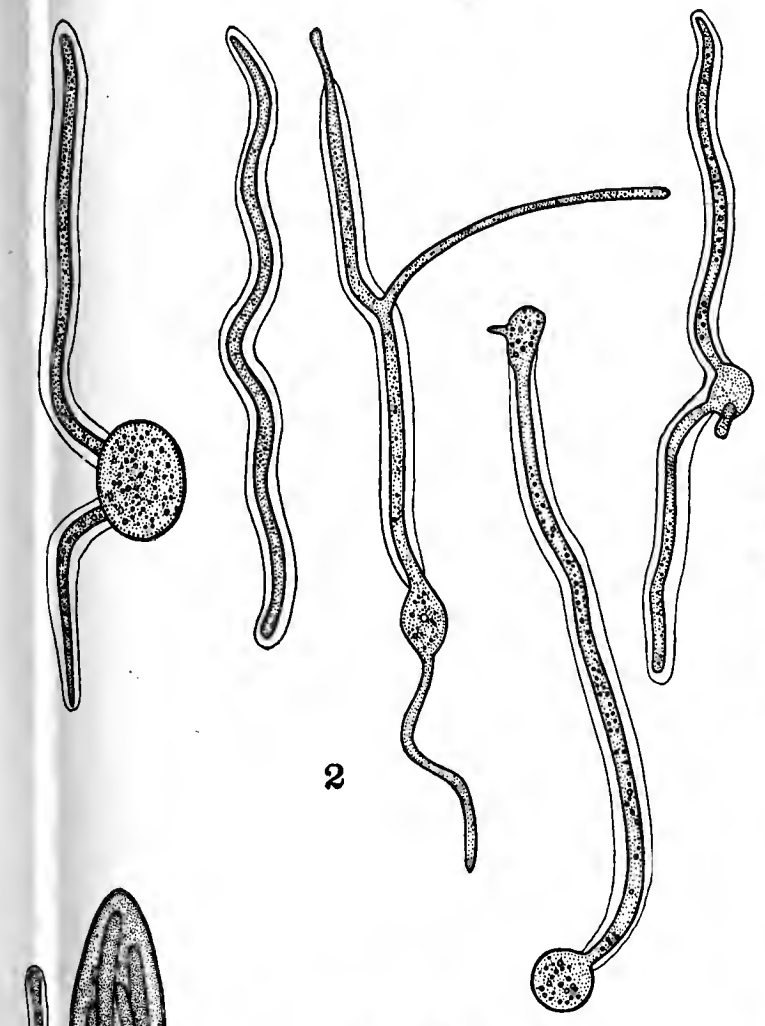
THE HYPODERMATACEAE OF CONIFERS.



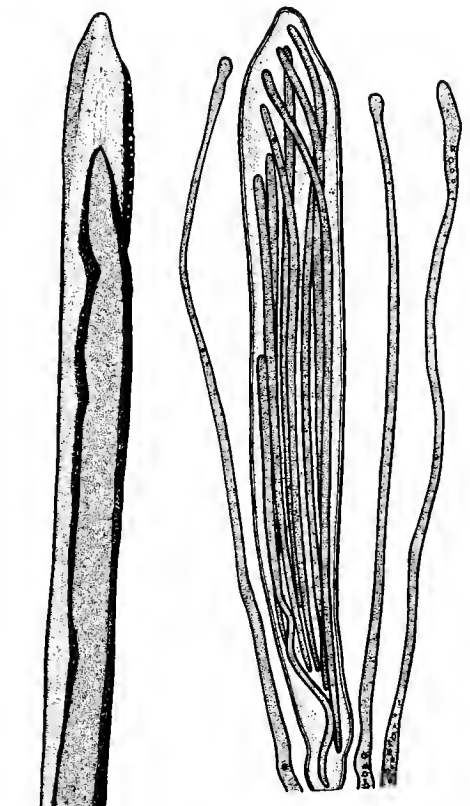
1



3



2



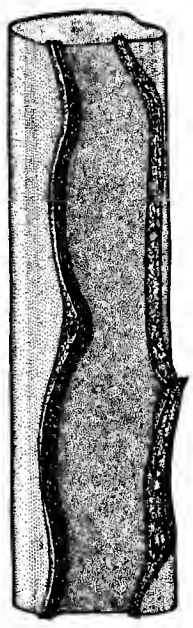
7

5

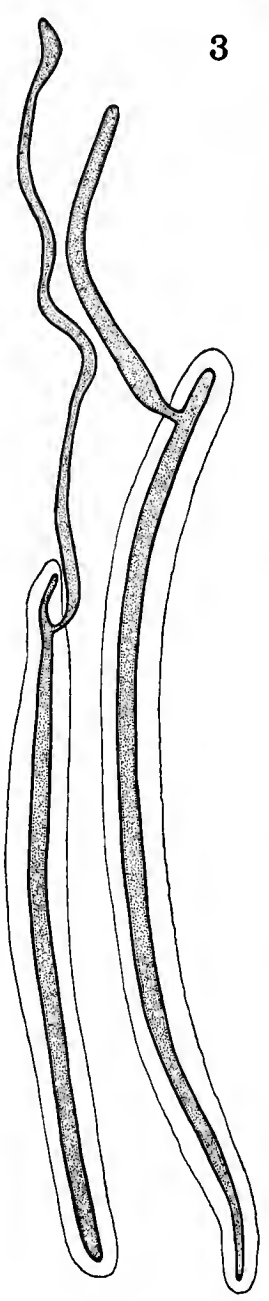
9

10

4

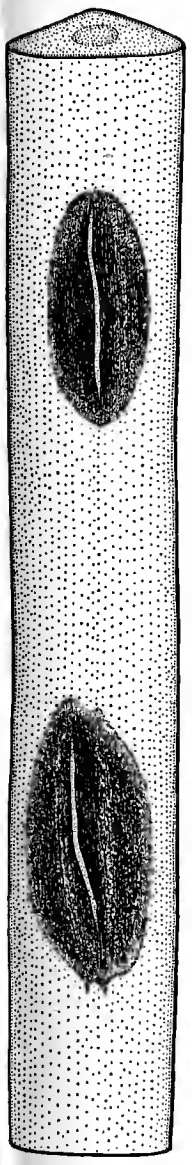


6

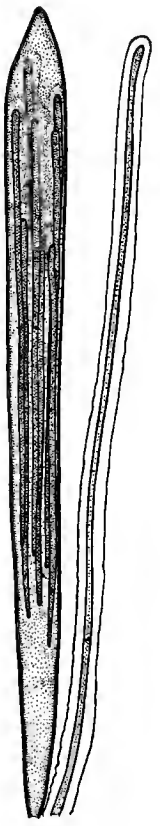


8

THE HYPODERMATACEAE OF CONIFERS.

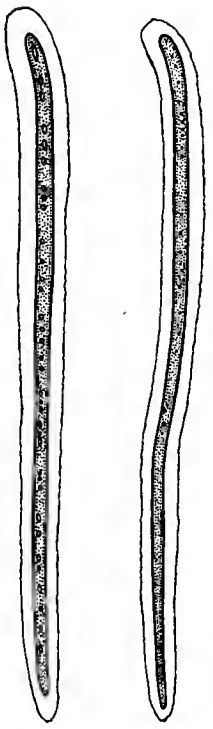


1

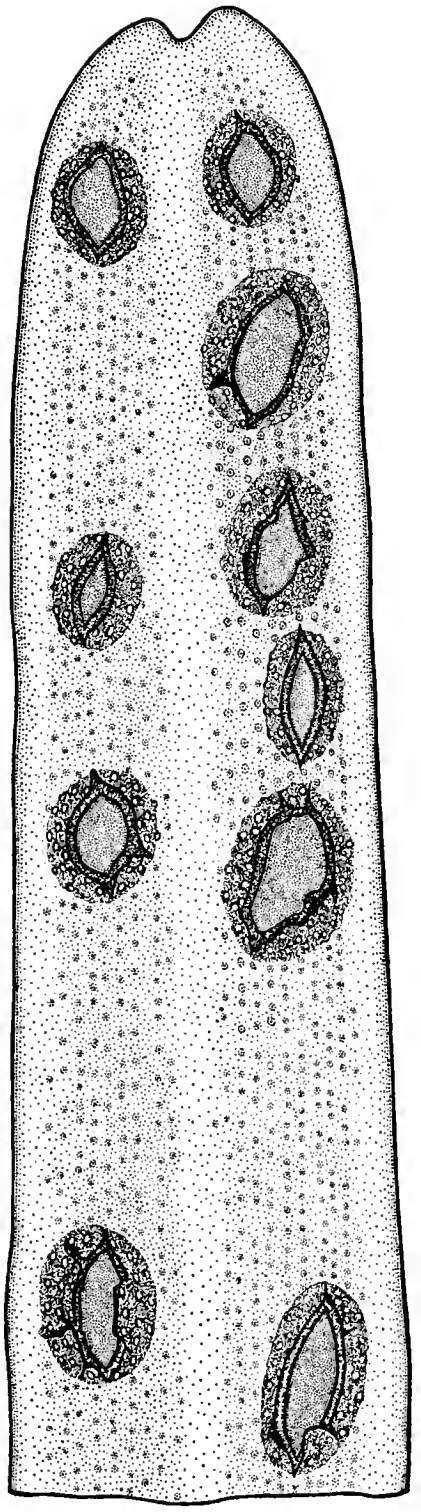


2

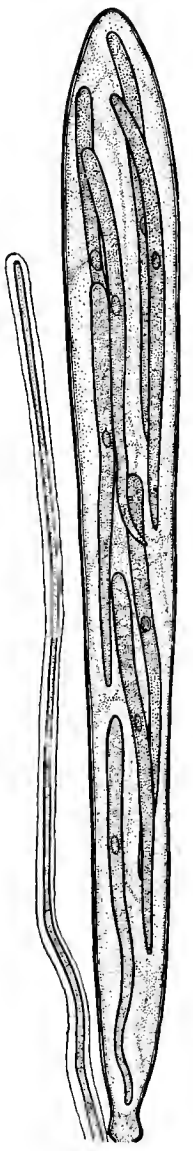
3



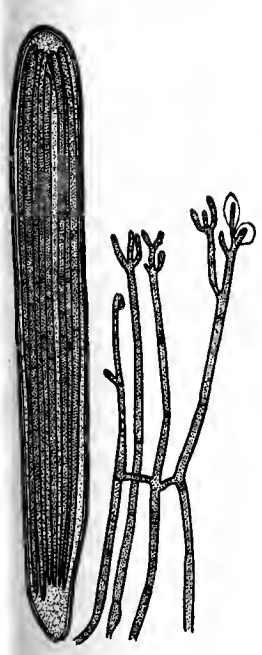
4



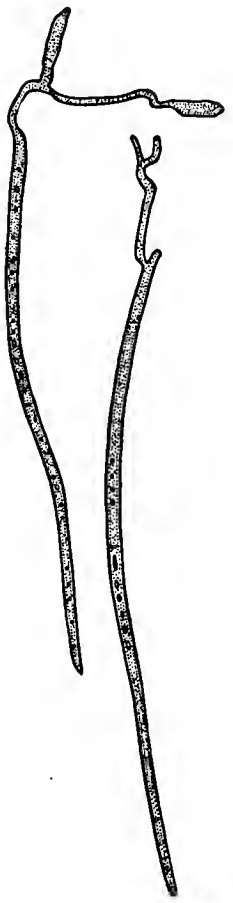
5



6

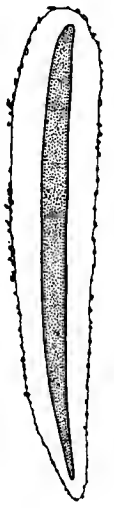


8

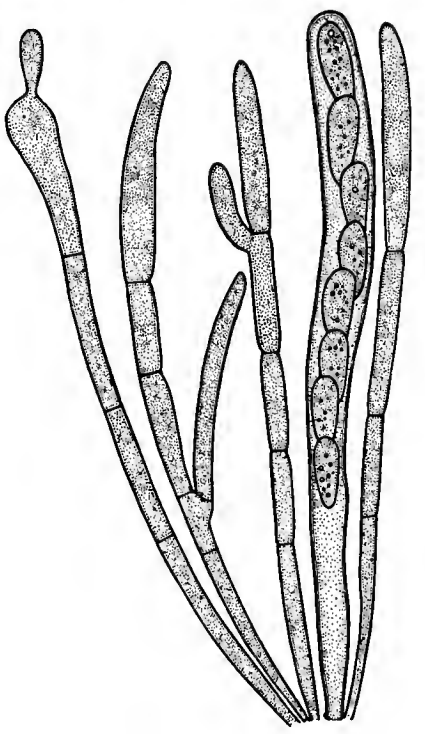


9

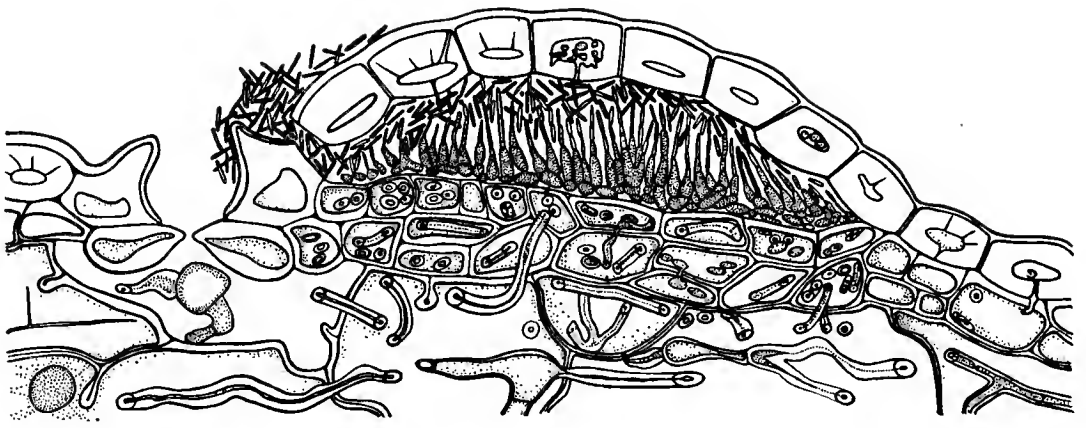
10



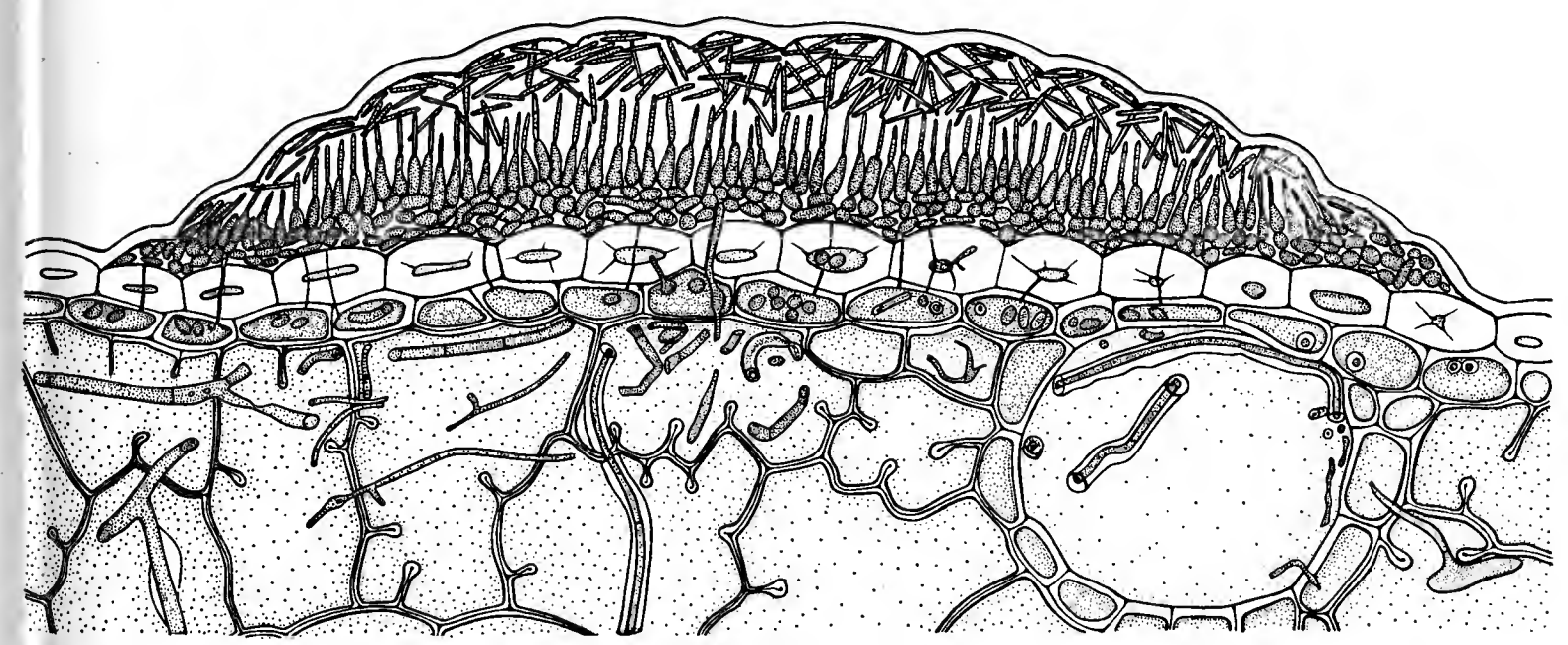
7



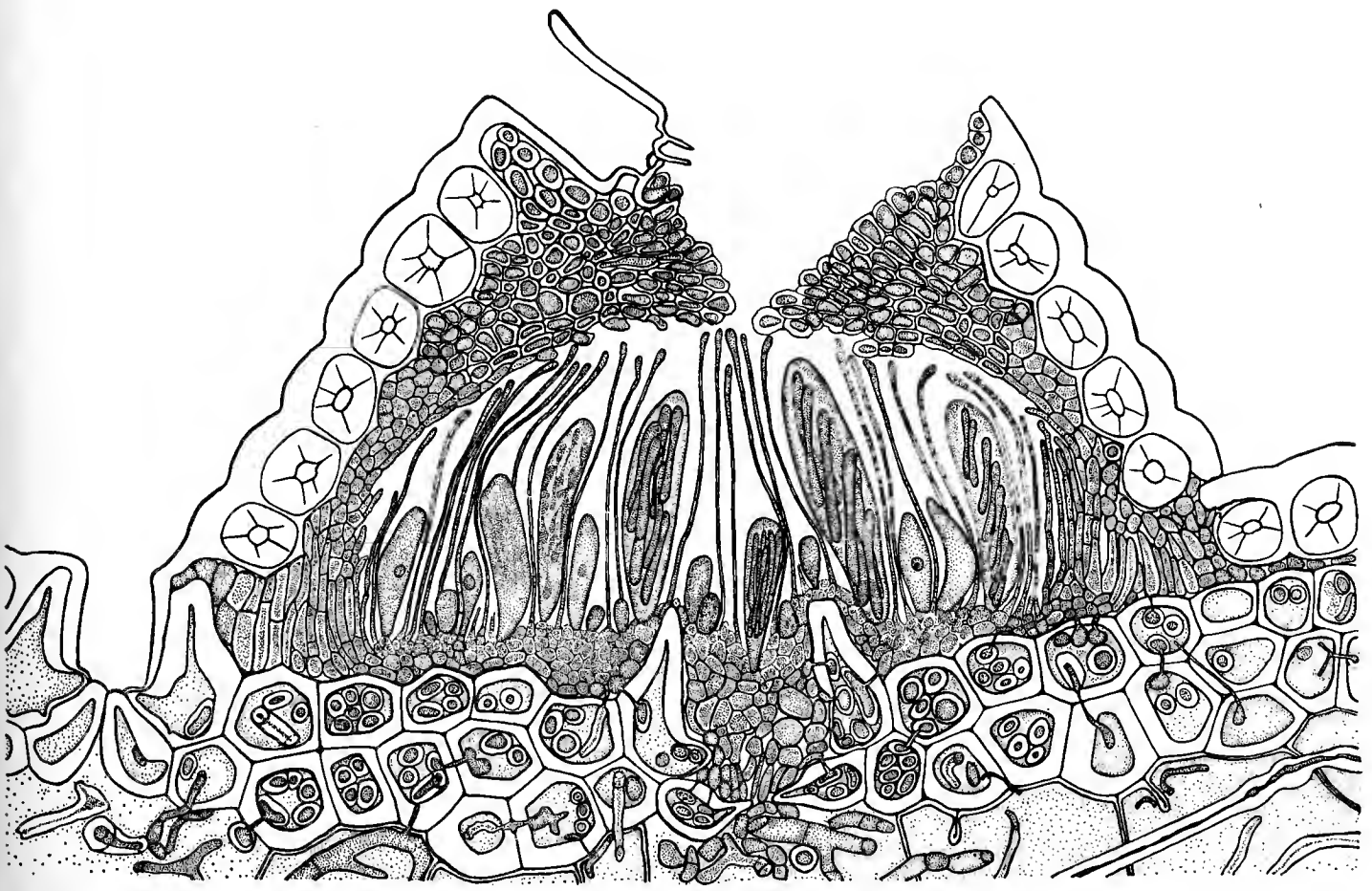
11



1



2



3

THE HYPODERMATACEAE OF CONIFERS.

PUBLICATIONS PREPARED AT THE ARNOLD ARBORETUM

Of the following publications, the first can be obtained from the ARNOLD ARBORETUM, the second and third from HOUGHTON MIFFLIN COMPANY, Boston and New York, and the fourth from the MACMILLAN COMPANY, New York.

THE SILVA OF NORTH AMERICA; A DESCRIPTION OF THE TREES WHICH GROW NATURALLY IN NORTH AMERICA EXCLUSIVE OF MEXICO. By Charles Sprague Sargent. With 740 plates drawn from nature by Charles Edward Faxon. 14 vols. f°. Boston and New York, 1891–1902. A few sets in which some pages in vols. 4 and 14 are supplied by photostat copies.

Price $300.00

——The same. Broken sets. Number of volumes and prices on request.

——Complete sets of the 740 plates drawn for the "Silva." *Price* $100.00

——Selected plates (according to number selected)

Price each $0.50 to $1.00

TREES AND SHRUBS. Illustrations of new or little known ligneous plants. Prepared chiefly from material at the Arnold Arboretum and edited by Charles Sprague Sargent. With 200 plates drawn by Charles Edward Faxon. 2 vols. f°. Boston, 1905–1913. *Price* $40.00

A MANUAL OF THE TREES OF NORTH AMERICA EXCLUSIVE OF MEXICO. By Charles Sprague Sargent. With 783 illustrations from drawings by Charles Edward Faxon and Mary W. Gill. Second edition reprinted with corrections. 910 pp. 8°. Boston and New York, 1926. *Price* $12.50

MANUAL OF CULTIVATED TREES AND SHRUBS HARDY IN NORTH AMERICA EXCLUSIVE OF SUBTROPICAL AND WARMER TEMPERATE REGIONS. By Alfred Rehder. 37 + 930 pp. 8°. New York, 1927. *Price* $10.50

COLLECTIONS OF PHOTOGRAPHS TAKEN BY E. H. WILSON

THESE pictures represent trees and shrubs and different types of vegetation found in eastern Asia, Africa, India and in Australasia; they have been taken by Wilson with a full knowledge of his subjects and their scientific importance. They may be obtained from the Arnold Arboretum, Jamaica Plain, Mass.

CHINESE PHOTOGRAPHS TAKEN 1907–1910

Series 1. 500 photographs (each 8½ x 6½ inches) taken 1907–1909, with typewritten index *Price* $250.00

Series 2. 350 photographs (size as above, numbered 01–0350) taken 1910, with typewritten index *Price* $175.00

JAPANESE PHOTOGRAPHS TAKEN 1914

A series of 600 photographs (size as above, numbered x 1–x 600) with typewritten index *Price* $300.00

PHOTOGRAPHS OF THE EXPEDITION TO EASTERN ASIA 1917–1918

A series of 700 photographs (size as above, numbered N 1–N 700) with typewritten index *Price* $350.00

This series consists of the following sets: Liukiu Islands (60 photographs) *Price* $30.00.—Bonin Islands (30 photographs) *Price* $15.00.—Japan (50 photographs) *Price* $25.00.—Korea (310 photographs) *Price* $155.00.—Formosa (250 photographs) *Price* $125.00.

PHOTOGRAPHS OF THE EXPEDITION TO AUSTRALASIA, INDO-MALAYA AND AFRICA, 1920–1922

A series of 522 photographs (size as above, numbered y 1–y 522) with typewritten index *Price* $261.00

This series consists of the following sets: Australasia (245 photographs) *Price* $123.00.—Indo-Malaya (93 photographs) *Price* $47.00.—Africa (184 photographs) *Price* $92.00.

Postage not included in the prices quoted above.

Selections from these photographs will be furnished at an advanced price.

PUBLICATIONS OF THE ARNOLD ARBORETUM

THE following publications can be obtained from the ARNOLD ... Jamaica Plain, Mass.

THE BRADLEY BIBLIOGRAPHY. A guide to the literature of ... including books and articles in the proceedings of learned ... scientific and popular journals, published in all languages to ... nineteenth century. Compiled under the direction of Charles ... gent by Alfred Rehder. 4°. 5 vols. Cambridge, 1911–1918.

Bound ...

Unbound ...

PLANTAE WILSONIANAE. An enumeration of the woody p... western China for the Arnold Arboretum during the ... 1910 by E. H. Wilson. Edited by Charles Sprague ... (9 parts). Cambridge, 1911–1917.

Parts 1–4 are out of print; the remaining parts each $1.50

THE GENUS PINUS. By George Russell Shaw. f°. 9... bridge, 1914.

CATALOGUE OF THE LIBRARY OF THE ARNOLD ARBORETU... the direction of Charles Sprague Sargent by Ethelyn Mari... vols. Cambridge, 1914–1917.

Vol. I. Serial publications—Authors and titles. Unbo...
Vol. II. Subject catalogue.

THE CHERRIES OF JAPAN. By Ernest Henry Wilson. 8°. ... Cambridge, 1916. With supplement of 3 pp.

THE CONIFERS AND TAXADS OF JAPAN. By Ernest Hen... 91 pp. 59 pl. Cambridge, 1916.

Postage not included in the prices quoted abo...

GUIDE TO THE ARNOLD ARBORETUM. 8°. 33 pp. 7 pl. 2 ...

JOURNAL OF THE ARNOLD ARBORETUM. A quarterly jour... the Arnold Arboretum. Subscription $3.00 per year. Pric... $1.00. Back numbers on hand of Vols. VI. VII. VIII. ... (except No. 3 of Vol. X).

BULLETIN OF POPULAR INFORMATION, Series 3, illustr... spring and autumn, about 18 numbers per year, together wi... page. Subscription $1.00 per annum.

A limited number of series 2, Vols. I–II (1915–16), VI ... (1924–26), and of Series 3, Vol. I–V (1927–31) can be ... each.

Reprints from the JOURNAL OF THE ARNOLD ARBORETUM:

NORTHERN TREES IN SOUTHERN LANDS. By Ernest H. ... 1923.

ENUMERATION OF THE LIGNEOUS PLANTS OF NORTHERN ... fred Rehder.—To be concluded in about 5 parts.

Part I (Ginkgoaceae to Ranunculaceae). 76 pp. 192...
Part II (Lardizabalaceae to Rosaceae). 88 pp. 1924.
Part III (Leguminosae to Sapindaceae). 77 pp. 1 pl. ...

Price ...

CORRECTIONS AND EMENDATIONS OF THE SECOND EDITI... MANUAL OF THE TREES OF NORTH AMERICA. By C. S. ... 1926.

THE SPONTANEOUS FLORA OF THE ARNOLD ARBORETUM ... Palmer. 57 pp. 1 pl. 1930.

CONTRIBUTIONS TO THE FLORA OF THE NEW HEBRIDES; ... BY S. F. KAJEWSKI IN 1928 AND 1929. By A. Guillaumin. ... 1 pl. 1931–1932.